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QWG AOR SOLDIER MODELLING WORKSHOP
VOLUME II: DISCUSSIONS

BY

Lisa Willner, LFORT 3

JULY 1998

OTTAWA, CANADA

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Lisa Willner, LFORT 3

Recommended by: Paul Bender
P. Bender
LFORT

Approved by:
G. Lafond
DOR(J&L)

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ABSTRACT

Programs to enhance the capability of the dismounted soldier have been started in all the ABCA countries. Models and measures of effectiveness need to be in place to assess changes in the soldiers' capabilities due to enhancements to their clothing and equipment. A joint QWG AOR/TTCP workshop was held 27 to 31 January 1997 in Ottawa to discuss programs of work, available models, and measures of effectiveness. This research note contains a summary of the discussions held during the workshop. Agreement was achieved on a set of definitions and on a way ahead.

RÉSUMÉ

Dans tous les pays de l'ABCA, on a commencé des programmes pour accroître la capacité du soldat démonté. Il faut que des modèles et des mesures d'efficacité soient en place pour estimer les changements attribuables aux améliorations d'équipement et de vêtements. Un atelier combiné de QWG AOR et TTCP a eu lieu du 27 au 31 janvier 1997 à Ottawa pour discuter les programmes de travail, les modèles disponibles et les mesures d'efficacité. Ce compte rendu contient un sommaire des discussions qui ont eu lieu pendant l'atelier. On s'est mis d'accord sur une suite de définitions et sur une direction à suivre.

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QWG AOR SOLDIER MODELLING WORKSHOP
VOLUME II: DISCUSSIONS

INTRODUCTION

1. The uncertainty and unpredictability of future conflict has changed the emphasis in force structure to light mobile forces with versatility, adaptiveness and responsiveness. Heavy forces are lethal and survivable, but demand a large logistical effort for deployment and sustainment. The new light forces are deployable, but lack lethality and survivability. This change of emphasis along with the reality for the dismounted soldier faced with a wide range of lethal hazards has caused the ABCA and NATO countries to create programs to enhance the capability of the dismounted soldier.

2. In the past, the procurement of dismounted soldier equipment by targeting specific pieces of equipment, e.g. personal weapons, helmets, etc. led to specific performance enhancements for the soldier role, but was sub-optimal for the composite battlefield performance of the dismounted soldier. There was insufficient effort to coordinate the clothing and equipment, this coordination being essential for a fully integrated and modular system for the dismounted soldier.

3. The fundamental functions of a fighting soldier on the battlefield are: to see, hear, communicate, fire, survive and move. Five distinct capability areas need to be improved to allow the soldier to complete the combat mission and perform his assigned tasks: lethality, command and control, survivability, sustainability and mobility. The goal of the Canadian Integrated Protective Clothing and Equipment (IPCE) program, like the goals of the other NATO soldier enhancement programs, is to coordinate and integrate a modular combat system offering significant capability enhancements in the five NATO capability areas of lethality, command and control, survivability, sustainability and mobility.

4. Advances in the five NATO capability areas have arisen from improvements in various technologies such as advances in munitions, sensors, communications, and information processing capabilities, improved protection to various threats as well as improved vision and navigation devices. In order to assess the improvements brought about by the new technologies, it is necessary to have models that are able to capture the relevant parts of the soldiers' battlefield. It is also necessary to have the measures defined, which will allow the proper assessments to be made.

BACKGROUND TO WORKSHOP

5. At the QWG AOR meeting held in the UK in July 1995, Dr. D. Oxenham suggested that TTCP WTP 6 and QWG AOR become involved in joint studies and workshops. At that meeting it was agreed to hold a joint workshop on two soldier combat models, Close Action Environment (CAEN) from the UK and Integrated Unit Simulation System (IUSS) from the US, and their application to advanced soldier system programs. These were the only two developed computer models representing the individual soldier in sufficient detail to be useful in current soldier modernization programs. The US HOD, Mr. Walter Hollis, advised that he would produce a draft plan of action to integrate the work of TTCP and QWG AOR. The workshop was scheduled for March 1996. Unfortunately, not all the required participants were available in the desired time frame, and the workshop was cancelled. Then TTCP WTP-6 was temporarily disbanded.

6. In July 1996, at the meeting of the 22 QWG AOR held in the UK, Mr. Hollis of the US suggested that a workshop be held under the combined auspices of QWG AOR and TTCP for the exchange of information on CAEN and IUSS. In August 1996, Mr Hollis attended a bilateral OR Symposium held in Ottawa where he suggested that the workshop be pursued under the auspices of QWG AOR. This new workshop would focus on modelling the soldier, and in particular, measures of effectiveness, rather than an explicit comparison of CAEN and IUSS. It was agreed that Canada would take the lead in setting up the workshop and extend an invitation to QWG AOR members. The QWG AOR meeting was to be held 5-11 February 1997 in Ottawa, so it was decided to hold the workshop in Ottawa as well, having it take place 27-31 January 1997.

7. At a TTCP Technical Liaison Group (TLG) -8 (Soldier System Modernization) meeting held in Toronto, in June 1996, Australia and the UK agreed to investigate the possibility of organizing a workshop aimed at developing a set of measures of effectiveness

which would be acceptable to all nations. The measures of effectiveness would be used to evaluate the changes in effectiveness of dismounted soldiers as a result of changes in their clothing and equipment. As a step towards co-operation in this area, TLG-8 agreed to co-sponsor the workshop in January. An invitation to the workshop was therefore also extended to TLG-8 members.

8. As NATO Panel III WG-4 is also working on soldier modelling, invitations were sent to TTCP TLG-8 members, TTCP WTP-6 points of contact, QWG AOR points of contact, and some NATO Panel III WG-4 members. Papers were elicited from scientists from the UK, US, Australia, New Zealand, Canada (including scientists from DCIEM, DREV and DRES) and the Netherlands known to be working in the area of soldier system analysis. Participants at the workshop also included several contractors. A list of participants is contained in Annex A.

WORKSHOP OBJECTIVES

9. The objectives of the workshop were:

a. to exchange information on national efforts on soldier system modelling;

b. to agree on a set of common measures of effectiveness;

c. to determine areas of possible collaboration and propose a way ahead; and

d. to provide input to the QWG AOR meeting the following week.

APPROACH

10. The first two days of the workshop were set aside for presentations. Canada, Australia and the Netherlands gave their presentations on the first day. The UK and the US made their presentations on the second day. The New Zealand presentation and one extra Canadian presentation were made Wednesday morning. The rest of Wednesday and Thursday were reserved for discussions. On each of these two days, the group was divided into three syndicates as shown on the agenda in Annex B. Participants chose their own groups with the restriction that delegates from each country should split themselves up among the syndicates. The topic for the Wednesday session was modelling and measures of

effectiveness. Peter Dooley from the UK presented a list of questions that he felt should be covered in the discussion groups. These questions are included in Annex C. Two of the syndicates used those questions as a basis for discussion. The topic for Thursday was data collection and data requirements. At the end of each of the two days of discussion, the syndicates made presentations on what they had discussed. Friday was reserved for general discussion including agreement on a way ahead, on a set of common definitions, and direction for the proposals to be made to QWG AOR.

DISCUSSIONS

11. In general, the Wednesday groups explored issues related to modelling and measures of effectiveness. In particular, they discussed the system to be optimized and how to go about doing that optimization.

12. The first group started with the following question: what is the system we are trying to optimize: company, platoon, section/squad, fire team, or individual? The emphasis, they decided, was on the levels of company, platoon, and individual. Secondly, they looked at the question: what military contexts are appropriate to consider? This question is important because different contexts may require different optimizations. It is necessary to consider different types of activity, for example, take ground, hold ground, and destroy enemy. The context must also be related to the level to be optimized (e.g. company, platoon, individual, etc.). Thirdly, they considered the question: what outcomes (not necessarily military) are desired? They decided that the desired outcome was to achieve the stated mission within the given constraints, e.g. time limits, number of casualties, resources, etc. Once again they decided that the desired outcome was specific to context, including level. Fourthly, they considered definitions for Measure of Performance, (MOP), Measure of Effectiveness, (MOE), Measure of Outcome, (MOO), and Measure of Capability, (MOC). They defined the MOP as data point(s) measured on a scale under stated conditions. The MOE was defined to be the basis for a value judgement taken in the given context. It should take into account at least one MOP. The MOO, they decided, has no direct value judgement (like performance) but is a statement of single mission results, including constraints. They decided that the MOC may be high level (Australian perspective), or refer to capability area (combination of specific performances) or give the capacity to "fight on" after completing the stated mission.

13. The second Wednesday group considered similar questions. They started off by looking at their goals: to define modelling that supports the development of a "soldier system" which enables a deployed force to best achieve their mission in a range of military tasks; and to develop a soldier system that enhances individual, group and organizational performance to achieve a broad range of military operations. They then considered revised objectives: a definition of a methodology that will lead to high level parameters that Users will understand; and identification of the relationship of these high level parameters to tools of interest to this workshop.

14. The group approach started by an attempt to structure in and define the "system". They then investigated the scenario/ activity matrix, which led to a debate on outcomes and their measurement. The group then returned to the system with a discussion of MOPs and MOEs and their inappropriateness. This discussion led to "component attributes" and "conditional factors" which led to the group recommendations.

15. They defined **the system** as that military unit that will undertake the particular military task. This was reviewed in the context of scenarios. The generation of the high level requirement matrix (scenario versus activity) includes OPFOR, environment and terrain. In terms of measures, they considered two: Measure of Outcome and Measure of Success. They decided that the **outcome** answered the question: has the military objective been achieved? It is a recognisable event that can be achieved or not. They suggested that **measures of success** answer the question: how well did we do? These measures of success can be measured. As an example, the group considered a mission to attack a hill. The outcome might be that the company takes the enemy position within a given time. The measures of success might be the percentage killed, the percentage injured, the time taken, the recovery time, the ammunition left and the artillery ammunition used. They considered that MOPs and MOEs were component attributes that measured or assessed performance criteria, including equipment specification and human factors. Conditional factors, such as terrain and environment were considered to be part of the scenario. As achievements, the group felt that they had developed an understanding of what modelling tools need to do in order to aid military decision making, and that they had defined a methodology that would provide high level user requirements. As a way ahead, they suggested:

a. identify common scenarios and activities from those scenarios for collaboration;

b. agree on common measures of success for those scenarios; and

c. agree on component attributes.

16. The third Wednesday group looked at the issue of what recommendations to make to the QWG AOR meeting the following week. Their recommendations, which provided the basis for the recommendations that came out of the workshop, were the following:

a. that CAEN and IUSS should form the basis of soldier system assessment models;

b. that a CAEN-IUSS working group be formed to:

- develop and implement a technical and administrative roadmap to ensure a configuration controlled, standardised suite of soldier system assessment models
- to emphasize:
  - efficient use of models
  - optimized continued development of models
  - linked usage of models

c. that a data working group be formed to:

- develop and implement a technical and administrative roadmap to coordinate soldier system trials and tests, experimental design, and results interchange

17. The three Thursday groups discussed issues related to human factors and data collection.

18. The first Thursday group considered the following topics: scenario definition, MOE definition, baseline soldier data, data for the improved soldier, system data, doctrine, threat definition and tactics. They started by looking at the interactions between the soldier, the environment (the terrain, the time of day, the weather, the threat, etc.) and the equipment. They discussed MOEs (success level), tactics and changes to tactics, and behavioural response. They considered data inputs for man (target audience description – RSG 24 work, skill/capability data, and group dynamics), for man/environment interactions (e.g. climatic responses, and responses to enemy action such as suppression), for equipment (such as radios, weapons, and clothing), and for the man/equipment interaction (for example, the effects of suppression, decision-making and information-processing). They then looked at the model of man as input/processing/output. For example, possible inputs are vision and touch. Possible processing examples are attention and cognitions. The outputs are measurable physical responses. Their example input/processing/output model is shown in Annex D.

19. The second Thursday group started by looking at the data requirements, in particular the human performance and human factors data required. They discussed which human factors data were essential and which were available. They decided that field trials data were essential, and that collaboration and exchange of data were essential. They came up with the essential factors in deciding if data should be collected:

a. so what? how relevant are the data to questions being asked?

b. who cares? what is the impact of the thing being measured? and

c. can the data stand in as proxy for other data (e.g. heart rate)?

They discussed availability of data and the fact that, although there are many sources, older data may be less relevant because of shelf life. For example, 1970s sizes and shapes are different than current ones. One outstanding issue is reaching agreement on definitions for data. For example, there are four different definitions for chest circumference in NATO. Data may be collected from the laboratory, from field trials, or by other methods, but in order for the performance measures to be of later use, the conditions in effect at the time of measurement need to be known. The utility of data items is tied to the Effectiveness methodology. The effectiveness measures are dependent of other scenario components such as OPFOR/Threat ("Baddies").They then discussed a method of collaboration for data collection and exchange and suggested the use of a World Wide Web site as an archive. The data could be organized like a Requirements table with an open structure for data classification. There is a need for common terms. Information would need to be provided on conditions during the trial and the recording means. They outlined a structure for the soldier data and listed examples of the types of data required. See Annex E. As a summary, to minimise semantics, they suggested the following criterion to resolve questions on effective and efficient data collection, archiving and dissemination by establishment of data worth: So What?

20. The third Thursday group, led by Dr. George Mastroianni, started off by looking at the question of digitization and its proper role. The topic of digitization covers a wide area of concern, including NBC alerts and air strikes. Position information needs to be exchanged but there is also a psychological need for human exchange, and it allows the commanders the ability to project their personalities. It is important to ensure that only relevant information is sent to the soldier. There is also the question of the influence of technology on performance - confidence versus hesitation. They posed some questions: What is the appropriate match of equipment and level of command? What should the soldier (section leader, platoon leader, company commander) be seeing/hearing/communicating at each phase of combat? There are possible problems of distraction from the mission and of morale.

21. The group discussed two areas of emerging interest: MOUT and OOTW. To study MOUT involves modelling dynamic urban terrain. It will also require modelling more complex sensory/motor aspects than has been done in the past. There will also be the requirement for the development of data collection methods/procedures. To study OOTW and other non-lethal situations, it will be necessary to understand the effectiveness of NLW. There is a need to model peacekeeping and other operations. The group suggested that ongoing data collection methods should be established.

22. The third Thursday group went on to discuss terrain/environment co-operation. As a starting point, they noted that a first-world country's armed forces have to be prepared to fight on terrain and in environments not found on its own territory. They suggested four levels of international cooperation:

a. Let our army train and test on your country's terrain;

b. Let our representatives observe your trials and exercises;

c. Let us request that you collect specified data items for us during your trials; and

d. Let us share data and interpretations from your tests.

23. They then discussed situational awareness. It is necessary to predict the benefits of variations in situational awareness. The information needs vary based on tasks (combat/peacekeeping), position in the organization, and activity (patrol, firefight, etc.). What information or improvement in situational performance enhances performance, and how do we model it?

24. The group then looked at the sustainability data gap. They decided that the operational significance of sustainability was not well demonstrated (using current MOEs). The effects of component (physical) performance has typically been well-documented (MOPs). The collective effects (physiological/psychological) of hydration, subsistence, clothing and group equipment on operational performance measures needs to be documented. (They can affect lethality, survivability, and mobility.)

25. The group then discussed "the Model" versus "Real Life". In the model, soldiers are modelled as identical robots. In real life there are size variations, training variations, and behaviour variations. Looking at size variations, there are anthropometric data, there may be a variation in performance due to size, and there are possible behavioural compensations (e.g. speed of the slowest? Load distribution? Task optimisation?) Training variations may be caused by replacements, reservists and coalition warfare. Under behaviour variation, there are a lot of issues, including doctrine differences (especially important for coalition warfare) and "real" performance versus "peace" performance. There is a need for "soft operational analysis" on subjects such as suppression, using such methods as questionnaires and algorithms. How would the data be validated? Can historical comparison be used?

26. They looked at the difference between data and information. Data were seen to be detailed and to allow additional analysis, but to create a problem with overload. Information was defined to be processed data. It may be more relevant that the original data, but it is not complete. Another issue was the question of team performance versus individual performance. It is important to have data on team performance, not just data on individual performance. There are problems in assessing leadership, C^2I, and determining causation. The setting, environment and interrelations with doctrine/tactics are also important. Team

performance has close links with situational awareness. Doctrine/tactics are difficult variables to consider. They may be slow to change and because of the variation among countries, there is the risk of different interpretations of data and sharing/cooperation between countries is complicated.

27. This group felt that there should be a Special Working Party (SWP) on data. The SWP could produce a compendium/index of relevant publications/resources. It could establish a mechanism for searching and sharing among countries. It could ensure that comprehensive data exchange agreements are in place. The SWP could ensure co-ordination with acquisition programs. They strongly felt that besides a group set up for modellers, a group should be set up for algorithm and data exchange. They felt that the data and algorithm people should be in the same group and meet together so that:

a. Data people will measure and collect what the algorithm people want; and

b. The algorithm people won't design algorithms that make impossible-to-fulfil demands for data.

28. Peter Dooley provided a set of comments, which are found in full in Annex F. He suggested that one of the goals of the tool development community should be to strive towards a top-down approach for meeting the User objective: how effective will a particular set of equipment, tactics, training, etc. be in meeting my needs? At the top level, the User needs to formulate the high level requirements expressed as:

a. What types of missions am I required to undertake?

b. In what scenarios?

c. Given the types of mission, what will the make-up of my force be?

At the next level the questions for the User are:

d. How will I determine whether the mission is a success?

e. What measurements relating to the outcome of the mission will reflect how well I achieved that result?

At the mission level, either the mission is a success or it is not, and measures of its success or failure need to be given. The high level measurements should be simple and unambiguous, and should be technology independent. All the nations involved will have some commonality of missions and scenarios; however, each national perspective may result in additional or fewer measure of success parameters.

29. Until the tools are available that would enable performance to be predicted in terms that will allow judgements to be made at the decision-making level, Peter Dooley suggested that trials will be a good source of information on just how well missions are being achieved at present and how well they could be achieved with enhanced capability. As trials are expensive and difficult to organize, this is a potential, major area for collaboration. He then made the following recommendations:

a. that the workshop endorse a move to put a top down structure on the soldier modernization program based on the needs of the national Users;

b. that each nation determine what scenarios and missions are of interest to them to be used in establishing sets of common requirements;

c. that each nation shares with other nations (in its common sets) its perspective of what constitutes a successful mission;

d. that each nation then proposes its measures of success;

e. that these are reviewed within each set to determine whether they can be standardized or not;

f. that each nation declares the data that it would be interested in receiving from a trial associated with a scenario/mission of interest (if this is additional to the measures of success);

g. that each nation advises the other nations of any trials that are planned;

h. that each nation provides the agreed list of measurements to the others following the trial.

Further, he suggested that the terms MOE and MOP should be left in the domain of the tool developers, and they use them at several levels should they choose. He emphasized that the highest level measurements reflecting the achievement of User needs are **mission success (y/n)** and its associated **measures of success**. Additionally, he suggested that the tool developers provide a bottom up framework that will meet the needs of the User in decision making processes based on being able to predict the high level measures based on the top down requirements. Finally, he suggested that the needs of the above be embedded in a working group.

30. Steve Gribbon from CDC suggested that one way of summarizing current knowledge and models on soldier modernisation might be to use a Quality Functional Deployment (QFD) matrix. A summary of the QFD matrix can be found in Annex G.

CONCLUSIONS

31. The workshop made the following conclusions:

a. The problem of soldier system analysis is both an important one and a difficult one. The available models are limited in what they can do, and the analysis of the soldier and his clothing and equipment as a system is complex because of the human elements involved.

b. Collaborative effort in this area is useful, because all the countries are working on similar issues, and there is so much to do.

c. Agreement was achieved on an appropriate set of measures:

(1). Measure of Force Capability
- Scenario level (set of missions)
    - peacekeeping in Bosnia, Middle East war, special operations, etc.
- System configuration trade-offs
    - optimum system (allowing for modularity)

(2) Measure of Outcome

- Mission level (system)
    - objective achieved (while satisfying constraints)
    - time taken, losses sustained, resources expended
- Capability trade-offs (based on contribution to system effectiveness)
    - e.g. improve survivability rather than lethality

(3) Measure of Effectiveness

- Capability level (functionality)
    - e.g. lethality: number of detections, acquisitions, hits, kills, etc.
- Performance trade-offs (based on contribution to capability)
    - e.g. improve Phit rather than Pkill

(4) Measure of Performance

- Component level
    - e.g. detection range, accuracy
- Input/ Parameter values

(5) Measure of Cost Effectiveness

- factors in budget considerations/ constraints

ACTIONS RESULTING FROM THE WORKSHOP

32. The workshop made the following recommendations:

a. The UK would look into the costs and time involved to make CAEN compatible with other platforms.

b. The UK would also investigate the costs and time required to make CAEN object oriented.

c. It was also agreed that Canada would make the following two submissions to the QWG AOR meeting 5-11 February, 1997.

(1) Submission 1: It is recommended that a soldier system modelling SWP be formed to :

- develop and implement a technical and administrative roadmap, including provision for international funding, to ensure a configuration managed, agreed suite of soldier system assessment models
- to emphasize:
    - efficient use of models
    - optimized continued development of models and their algorithms
    - interoperability of models

(2) Submission 2: It is recommended that a data/methodologies SWP (for data collection and analysis) be formed to:

- develop and implement a technical and administrative roadmap for soldier system trials and tests, experimental design and analysis, and results interchange. Among the data needing to be collected are, for example, data on non-lethal systems, terrain, C4I, mobility, suppression, and human factors.

In the context of generating a basis for sharing data at the outcome level, it is further recommended that the SWP establish:

- common sets of scenarios/missions
- appropriate measures of outcome
- the high level data to be recorded in trials to meet national needs.

RESULTS OF THE WORKSHOP

33. The following outcomes were achieved as a result of the workshop:

a. A QWG SWP on Soldier System Analysis (SSA) chaired by Australia was agreed to at the QWG AOR meeting. The terms of reference and task analysis for SWP SSA are found in Annex H;

b. A set of definitions for Measures of Outcome, Effectiveness, and Performance based on the definitions agreed to at this workshop has been proposed for NATO. These definitions can be found in Annex I; and

c. A start was made towards international cooperation in the area of modelling and analysis in support of soldier modernization.

Name	Organization	Mailing Address	Telecom
Matthew A. Rosenblatt US	US Army Materiel Systems Analysis Activity	Director, US AMSAA Attn: AMXSY-EM (M. Rosenblatt) 392 Hopkins Road Aberdeen Proving Ground Maryland 21005-5071	Tel: (410) 278-2041 Fax: (410) 278-2043 e-mail: MATT@ARL.MIL
Philip J. DiSalvo LTC, US Army	ODUSA-OR (Office of Dep. Under Secretary of the Army for Operations Research)	Attn: SAUS-OR 102 Army Pentagon Washington, DC	Tel: (703) 693-7634 Fax: (703) 697-7748 e-mail: DISALPJ@HODA.ARMY.MIL
John A. O'Keefe US	US Army Soldier System Command	USA SSCOM Attn: SSCNC-AAM Kansas St Natick, MA 01760-5015	Tel: (508) 233-4881 Fax: (508) 233-4154 e-mail: jokeefe@msis.dmso.mil
Richard A. Strecker US	US Army Soldier Systems Command	US Army Soldier Sys Command Attn: SSCNC-AN Kansas St. Natick, MA 01760-5015	Tel: (508) 233-4967 Fax: (508) 233-5086 e-mail: RSTRECKE@NATICK-EMH1.ARMY.MIL
Andrew J. Finnie NZ	NZ Ministry of Defence	Defence House 15-21 Stout St Wellington New Zealand	Tel: (04) 4960 622 Fax: (04) 4960 859 e-mail:
Jeff R. Bright NZ	Army General Staff NZ Defence Force	Army General Staff HQ NZDF Private Bag Wellington New Zealand	Tel: (04) 4960 420 Fax: (04) 4960 493 e-mail:
John R. Coleby Head, Land Operations Analysis Group AS	Defence Science and Technology Organisation	Land Space and Optoelectronics Division PO Box 1500 Salisbury, South Australia 5108	Tel: +61 8 259 5614 Fax: +61 8 259 5624 e-mail: john.coleby@dsto.defence.gov.au
George Mastroianni US	Natick RDEC	SSCNC-YBH Kansas St Natick, MA 01760 USA	Tel: (503) 233-5826 Fax: (508) 233-5527 e-mail: gmastroi@natick-amed02.army.mil
Keith A. Jones US	Motorola SSTG	FXXI LW M/D H1250 PO Box 417 8201E McDowell Rd Scottsdale, A285252	Tel: (602) 441-8937 Fax: (602) 441-3361 e-mail: P26308@email.mot.com

Name	Organization	Mailing Address	Telecom
Paul Bender CA	DGOR/LFORT	NDHQ Ottawa, ON K1A 0K2	Tel: 996-1580 Fax: 992-3342 e-mail:
Michael Appleton CA	Computing Devices Canada	PO Box 8508 Ottawa, Ontario K1G 3M9	Tel: (613) 596-7801 Fax: (613) 596-7803 e-mail: michael.appleton@canada.cdev.com
Dr. Ken Ackles CA	DCIEM	Po Box 2000 North York, Ontario M3M 3B9	Tel: (416) 635-2098 Fax: (416) 635-2132 e-mail: ken.ackles@dciem.dnd.ca
LCol John Dick CA	DSAL	NDHQ Ottawa, ON K1A 0K2	Tel: (613) 995-2177 Fax: (613) 996-5177 e-mail: John.Dick@crad.dnd.ca
Ian Mitchell UK	CDA(Land) DERA	Room 010 Building Q10 DERA Fort Halstead Sevenoaks, Kent BR6 6LL England	Tel: 01459-514924 Fax: 01959-516027 e-mail:100347,331 dcompuserve.
Alistair Dunlop UK	D Science (Land)	Room 3354 Mod Main Building Whitehall London SW1A 2HB ENGLAND	Tel: 0171-218-7206 Fax: 0171-218-3271 e-mail:
Mike Wright UK	Centre for Human Sciences DERA	F131 Building Centre for Human Sciences DERA Farnborough Hants, GU14 6TO UK	Tel: (44) 1252 39 3884 Fax: (44) 1252 39 2122 e-mail: mjwright@dra.hmg.gb
Alan Moss UK	DERA Guns Department	DRA Fort Halstead Sevenoaks Kent TNA 7BP UK	Tel: 01959 51 4667 Fax: 01959 51 6025 e-mail: kmorgan@dra.hmg.gb
Peter Dooley UK	DERA Guns Deparment	DRA Fort Halstead Sevenoaks Kent TN 14 7BP UK	Tel: 01959 51 4667 Fax: 01959 51 6025 e-mail: kmorgan@dra.hmg.gb
Maarten Manders NL	TNO-PML Weapons & Weapon Platforms Division	TNO-PML PO Box 45 2200 AA RYSWYK Netherlands	Tel: +31-15-2843443 Fax: +31-15-2843959 e-mail: manders@pml.tno.nl
Kinfai Chan NL	TNO-PML Weapons & Weapon Platforms Division	TNO-PML PO Box 45 2280 AA Rijswijk Netherlands	Tel: 31-15-2843606 Fax: 31-15-2843959 e-mail: chan@pml.tno.nl

Name	Organization	Mailing Address	Telecom
Maj Linda Bossi CA	DCIEM Human Factors Specialist	DCIEM PO Box 2000 1133 Sheppard Ave W. Toronto, ON M3M 3B9	Tel: (416) 635-2197 Fax: (416) 635-2104 e-mail: linda.bossi@dciem.dnd.ca
Daniel Bourget CA	DREV	2459 blvd Pie-XI North Val-Belair Q.C. G3J 1X5	Tel: (418) 844-4228 Fax: (418) 844-4502 e-mail: daniel.bourget@drev.dnd.ca
Scott Duncan CA	DRES	P.O. Box 4000 Medicine Hat, AB T1A 8K6	Tel: (403) 544-4599 Fax: (403) 544-3388 e-mail: scott.duncan@dres.dnd.ca
Ann Marie Sibbald CA	PM IPCE-TD DSSPM	Louis St-Laurent Building 555 Boulevard de la Carrièr, Hull, Québec, K1A 0K2	Tel: (819) 994-9630 Fax: (819) 994-9619 e-mail: am.sibbald@issc.debbs.ndhq.ca
Maj M.A. Bodner CA	DLR 5-6 Project Director - IPCE Land Staff	National Defence Headquarters MGen George R. Pearkes Building Ottawa, ON K1A 0K2	Tel: 945-0269 Fax: 945-0478 e-mail:
LCol Jacques Levesque CA	DLR 5 - Infantry	National Defence Headquarters MGen George R. Pearkes Building Ottawa, ON K1A -0K2	Tel: 945-0279 Fax: 945-0478 e-mail:
Robert O'Brien US	Soldier System Command Natick R D&E Center	SSCNC-IW Kansas St Natick MA 01760 USA	Tel: (508) 233-4924 Fax: (508) 233-4483 e-mail: robrien@natick-embz.army.mil
Dale Malabarba US	SSCOM Natick RDE Center	Commander SSCOM Attn: SSCNC-AA Natick, MA 01760-5015	Tel: (508) 233-4940 Fax: (508) 233-4197 e-mail: dmalabar@natick-emh2.army.mil
Paul Short US	SSCOM Natick RDE Center	Commander SSCO Attn: SSCNC-AA Natick, MA 01760-5015	Tel: (508) 233-4256 Fax: (508) 233-4197 e-mail: pshort@natick.emh2.army.mil

Name	Organization	Mailing Address	Telecom
Keith Jones US	Motorola SSTG	PO Box 417 8201E McDowell Rd Scottsdale AZ 85252, USA	Tel: (602) 441-8937 Fax: e-mail:
LCol David S. Martin CA	DAD 4 (Doctrine)	CFLCSC DAD 4 PO Box 17000 Station Forces Kingston, ON K7K 7G4	Tel: (613) 541-5010 Ext 5912 Fax: e-mail:
Jan Chervenak US	Dismounted Battle Lab Simulation Center	USAIC - DBBL Attn: ATZB-WCS Fort Benning, GA 31904 USA	Tel: (706) 545-7000 Fax: (706) 545-7032 e-mail: Jan9538@AOL.COM
Steve Gribbon CA	Computing Devices Canada Integrated Protective Clothing and Equipment Project	Computing Devices Canada PO Box 8508 Ottawa, ON K1G 3M9	Tel: (613) 596-7393 Fax: (613) 596-7803 e-mail: steve.gribbon@canada.cdev.com
Lisa Willner CA	DOR(J&L)/LFORT	DGOR/LFORT National Defence HQ MGen George R. Pearkes Building Ottawa, ON K1A 0K2	Tel: (613) 995-8365 Fax: (613) 992-3342 e-mail: lwillner@dms-hp.ora.dnd.ca
Maj C. Noël de Tilly CA	DOR(J&L)/RWGT	DGOR/RWGT National Defence HQ MGen George R. Pearkes Building Ottawa, ON K1A 0K2	Tel: (613) 992-7998 Fax: (613) 992-3342 e-mail:

AGENDA FOR SOLDIER MODELLING WORKSHOP

27-31 JANUARY 1997

Monday January 27 1997

845	Administration Brief and Address by Chair	Ms. L. Willner
900	Welcome	Mr. G. Lafond
915	Canadian Soldier Modernization Program	LCol J.H.J. Levesque
945	Ballistic Protection Models and Generation of Personnel Vulnerability Data	Mr. D. Bourget
1030	Coffee	
1100	Materials/ Physiology & Body Region Hazard Assessment Models at DRES	Dr. S. Duncan
Lunch		
1300	Wargaming and Analysis in Support of the Integrated Protective Clothing and Equipment Projects	Ms. L. Willner
1345	Australian Presentation	Mr. J. Coleby
1500	Coffee	
1530	Dutch Presentation	Dr. M.P.I. Manders

Tuesday January 28 1997

845	British Presentations	Mr. A. Moss Mr. I. Mitchell
1015	Coffee	
1045	British Presentations	Mr. P. Dooley Mr. M. Wright
Lunch		
1300	American Presentations	Mr. D. Malabarba Dr. G. Mastroianni Mr. R. O'Brien
1500	Coffee	
1530	American Presentations	Mr. J. O'Keefe Mr. M. Rosenblatt

Wednesday and Thursday 29 and 30 January 1997

845	Syndicate Sessions
1015	Coffee
1045	Syndicate Sessions Resume
Lunch	
1345	Presentation
1430	Presentation

1515 Coffee
1545 Presentation
1630 Open Discussion

Wednesday 29 January 1997

1900 Hosted Dinner at National Arts Centre Le Café Restaurant
Soup of the Day
Grain-fed Chicken with Herb Bread Stuffing and Dried Cranberry Sauce
Screech Cake
Coffee or Tea
Glass of Wine

Friday 31 January 1997

845 Summary of Discussions
The Way Ahead - QWG AOR
Collaboration with TTCP TLG-8
Agreement of Actions

Syndicate Sessions

There will be 3 parallel syndicate sessions on Wednesday and Thursday.

Chairs for the 6 syndicates are:

1. Dr. A. Dunlop
2. Mr. D. Malabarba
3. Col J. Bright
4. Dr. G. Mastroianni
5. Mr. A. Moss
6. Mr. J. Coleby

Each syndicate will have a computer with Word, WordPerfect, Powerpoint and Harvard Graphics as well as a flip chart.

It is recommended that each syndicate choose a facilitator to write down what is being discussed on the flip chart, as well as a notetaker to summarize the discussion on the laptop to produce the presentation for the afternoon.

It is expected that delegates from each country spread themselves among the 3 syndicates each day.

Topics for Wednesday are:

What are appropriate measures of effectiveness, measures of performance and measures of outcome for soldier modelling?
What are appropriate models and other analytical tools?
What scenarios are appropriate?
What terrains should be considered?
What constitutes a reasonable threat?
What are problem areas to model/ analyse? How might they be tackled?

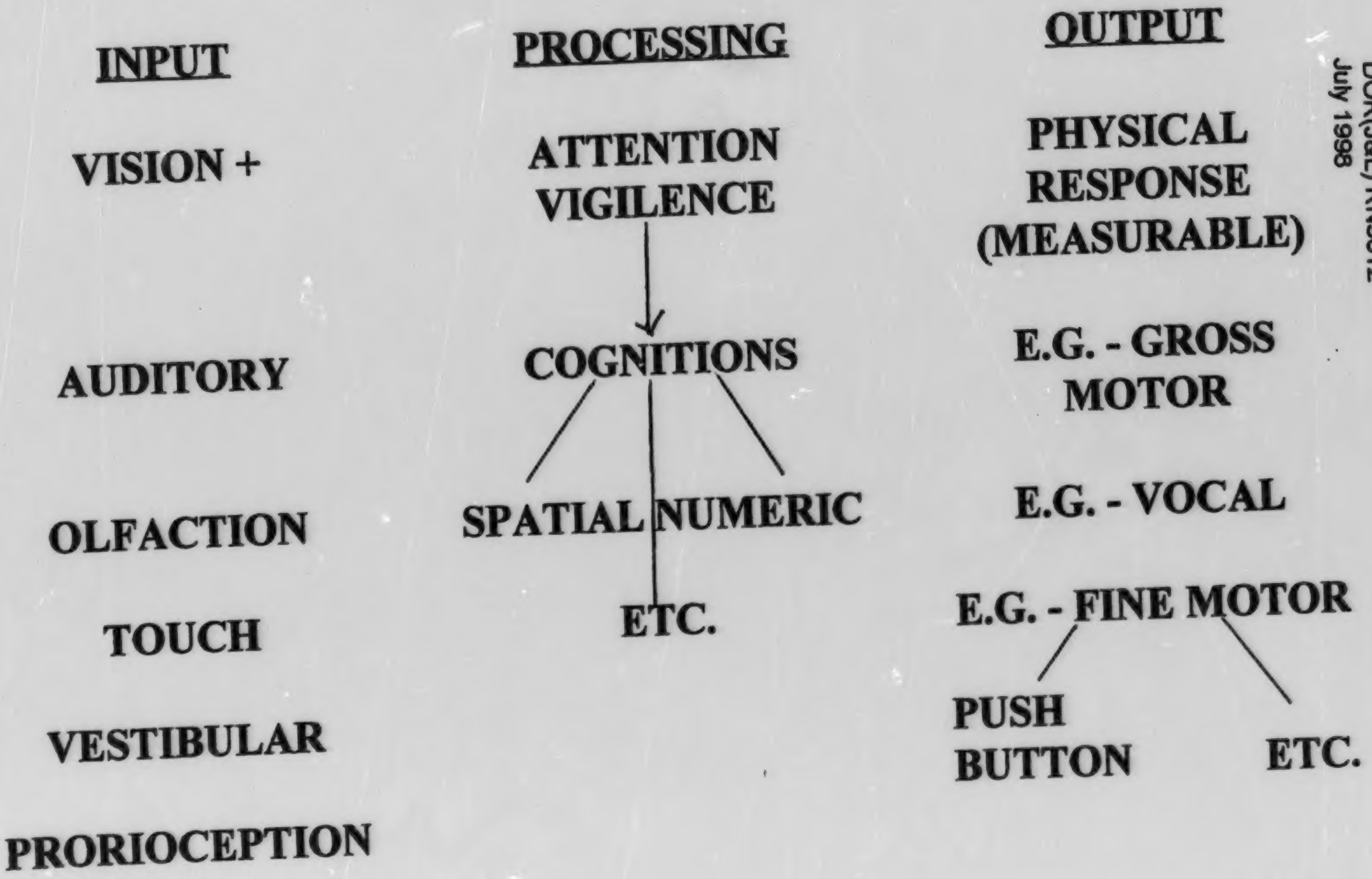
Topics for the Thursday are:

What are the data requirements?
What human performance data are available, and what are needed?
What human factors data are available, and what are needed?
What do we need to find out from field trials?
How can we collaborate in data collection?
What data can we exchange?

Discussion Questions

- What is the **System** that we are attempting to improve?
- What **military tasks** are appropriate to consider?
- What military **outcomes** are required?
- What are workshop **definitions** of measures of;
  - Performance
  - Effectiveness
  - Outcome
  - Capability

DERA



INPUT

VISION +

AUDITORY

OLFACTION

TOUCH

VESTIBULAR

PRORIOCEPTION

PROCESSING

ATTENTION
VIGILENCE

COGNITIONS

SPATIAL

NUMERIC

ETC.

OUTPUT

PHYSICAL
RESPONSE
(MEASURABLE)

E.G. - GROSS
MOTOR

E.G. - VOCAL

E.G. - FINE MOTOR

PUSH
BUTTON

ETC.

Data Discussion Points

“Do not allow anyone persuade you to learn ***more.”***

Sir Charles Napier’s excellent advice, per Drill & Rifle Instruction for the Corps of Rifle Volunteers 1860

Approach

- The Questions
  - Data Requirements
  - Human
    - Performance
    - Factors
      - Essential
      - Availability/Needed
  - Field Trials data
  - Collaboration and exchange of data
- A process of enthusiastic acclamation

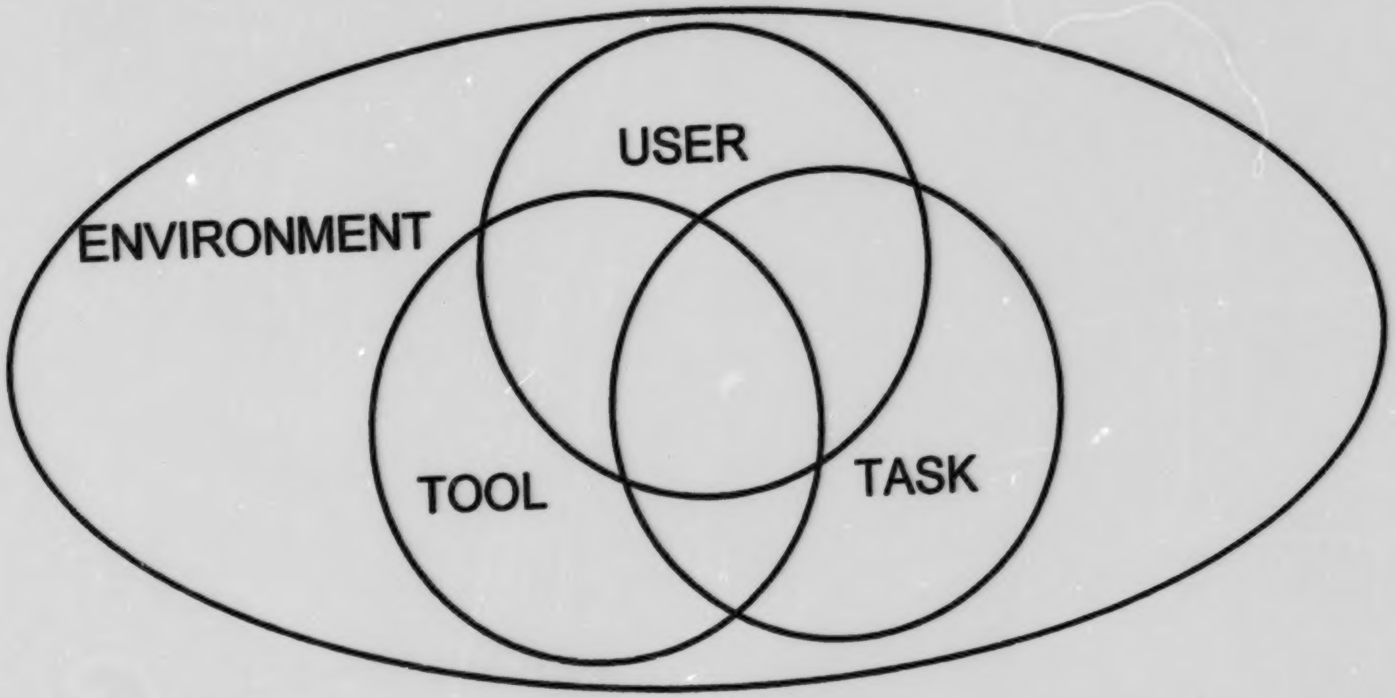
DERA

Method for collaboration for data

- World Wide Web site as archive
  - Data organised per Requirements table
  - Open structure for data classification
- Need for common terms
- Conditions applying to:
  - trials
  - recording means
- Sources for further information
  - Carbon based labour units (Who thought this up?)
  - On board models (What were they thinking?)

DERA

Soldier Data : Outline Structure


USER
ENVIRONMENT
TOOL
TASK

DERA

The Data Requirements: Types of data

User	Equip	Combat Functions	Environ	Capability	Cost
Physical Perceptual Cognitive Physiological Psychological	Physical Performance	Manoeuvre Firepower C2 I2 Protection Sustainability AD	Physical Organisational		

DERA

Data Examples

- Body Dimensions by body part
- Perceptual data
- Sensor characteristics (MoP)
- Acclimation
- Detector characteristics
- Chemical Attributes
- Weapon Characteristics
- Terrain
- Weather
- Clothing
- Field of View
- Suppression
- Tasks
- Training

DERA

Top-down methodology for infantry modernisation

ANNEX F
DOR(J&L) RN9812
July 1998

1. Objective of note

1.1.1 This note summarises and builds on the key aspects discussed in the first working party session on 29 Jan led by Col Bright (NZ) and then suggests a way forward for review.

2. Background

2.1.1 Based on a perception that the soldier modernisation tool development lacked a structured framework, high level questions were asked, in the open forum, concerning the need to establish what the infantry *was trying to do* and how should we assess *how well it was done* at the system level and indeed what the system level actually was.

2.1.2 The study group led by Col Bright took a top-down approach to the infantry modernisation issue.

3. The User perspective

3.1.1 Col Bright's requirement was the need to answer such questions as 'how effective will a particular set of equipment, tactics, training etc. be in meeting my needs?'

3.1.2 The point was made that, whatever tool development did at the lower and detailed levels, the information coming out at the higher level should directly reflect the requirements of the decision makers such as Col Bright.

3.1.3 Thus one of the goals of the tool development community should be to strive towards meeting this User objective.

4. Top-down approach

4.1 User requirements

4.1.1 In order that the modellers can meet the User's needs, it is clear that the User needs to formulate the high level requirements expressed as:

a) What types of missions am I required to undertake?
b) In what scenarios?
c) Given the types of mission, what will the make-up of my force be?

4.2 Achievement of mission

4.2.1 Thus for each scenario/mission:

a) How will I determine whether the mission is a success?

b) What measurements relating to the outcome of the mission will reflect how well I achieved that result?

4.3 The level at which overall measures should be made

4.3.1 The study team determined that the measurements of how well the activity had been achieved should be done at the system level.

4.3.2 The system was defined as that military formation that undertook the task.

4.3.3 It was agreed that the force make-up would be mission dependent and different nations could have different force sizes for the same mission.

4.4 Methodology

4.4.1 Thus, a matrix of missions within scenarios could be generated and then the mission could be defined from a military perspective. Again, from a military perspective, the factors that would describe just how well the (assumed successful) mission had been achieved determined.

5. High level measurements

5.1 Thought process

5.1.1 Simply the mission is either a success or not; given it is a success what are the measures of this success?

5.1.2 The group thus determined that, at this high and key level, measures of effectiveness/performance were perhaps inappropriate and confusing and should be terms under the control of the tool developers/equipment specifiers working from the bottom -up.

5.1.3 The high level measurement was determined as simple and unambiguous was all that was required and indeed technology independent.

5.1.4 All nations involved will have some degree of commonality of missions and scenarios; national perspective may result in additional or fewer measure of success parameters.

5.2 Subjective 'summing' of measures of success

5.2.1 If the various Users wished to prioritise and score measures of success to reflect their national perspective or to reflect a different emphasis in orders, then they could. This would allow them the opportunity of producing a single number outcome measurement.

5.2.2 This would naturally be highly subjective but entirely under their specific control and a minefield best avoided!

5.3 Trials and measures of success

5.3.1 Until the tools would enable performance to be predicted in terms that will allow judgements to be made at the decision making level, trials will be a good source of information on just how well missions are being achieved at present and how well they could be achieved with enhanced capability.

5.3.2 As trials are expensive and difficult to organise, this is a potential, major area for collaboration.

6. Recommendations

6.1.1 This list has not been discussed with the other study team members but is considered to be broadly in line with the conclusions reached.

6.1.2 Thus the specific recommendations are as follows:

a) that the workshop endorse a move to put a top down structure on the soldier modernisation programme based on the needs of national Users;

b) that each nation determines what scenarios and missions are of interest to them to be used to establishing sets of common requirements;

c) that each nation shares with other nations (in its common sets) its perspective of what constitutes a successful mission;

d) that each nation then proposes its measures of success;

e) that these are reviewed within each set to determine whether they can be standardised (or not);

f) that each nation declares the data that it would be interested in receiving from a trial associated with a scenario/mission of interest (if this is additional to the measures of success);

g) that each nation advises the other nations of any trials that are planned;

h) that each nation provides the agreed list of measurements to the other following the trial.

6.1.3 Further:

a) that the terms MOE and MOE should be left in domain of the tool developers and they can use these at several levels should they choose;

b) that the highest level measurements reflecting the achievement of User needs are mission success (y/n) and its measures of success associated.

6.1.4 Additionally:

a) That the tool developers provide a bottom up framework that will meet the needs of the User in decision making processes based on being able to predict the high level measures based on the top down requirements.

6.1.5 And finally:

a) That the needs of the above be embedded in a working group.

Peter Dooley

QWG AOR soldier modelling workshop member matrix are tuned for each specific approach, but the parameters of the matrix involve measuring, comparing, and contrasting two sets of elements. The Integrated QFD Approach™ is no different in this aspect, although the Core QFD Matrix has some elements that are not found in other approaches.

The Core QFD Matrix is the heart of the Integrated QFD Approach™ process. Crucial to the success of any attempt to use QFD in product or process applications is a complete understanding not only of the mechanics of utilizing the Core QFD Matrix, but also the reasoning behind the various sections.

The Core QFD Matrix is based on a matrix that is sometimes referred to as the "house of quality," and many of its conventions are similar. The house of quality is used to initiate a comparison of the customer needs with the technical requirements of a product, and is a major feature of the four-phased approach. The Core QFD Matrix is used in the Integrated QFD Approach™ in several different places, and although it may appear similar in form to the house of quality, it operates somewhat differently in the Integrated QFD Approach™, as will be explained in this and later chapters.

4.1 The Core QFD Matrix overview

The Core QFD Matrix is a product, service, and process planning matrix used to depict customer needs, design/service/business requirements, target design goals, and competitive product or service evaluation. The Core QFD Matrix is more than just the sum of its individual elements. It can be used as the vehicle to conduct the first foray into a total quality environment. As mentioned in Chapter 2, the Core QFD Matrix takes a vertical cut through the elements of RSM™ and can become the focal point for directed team building. This matrix is a fairly flexible approach to implementing QFD that can be configured in several different ways, depending upon the purpose or application of the matrix. Based upon various application environments, the Core QFD Matrix designed by the authors uses eight distinct components. Figure 4-1 illustrates these components, along with the eight steps that should be taken sequentially.

Prior to any construction of the Core QFD Matrix by a design, service, or project team, the effort to be addressed by the QFD process should be scoped by the management and staff. Whenever a multifunctional team is used to construct a QFD, there must be an initial definition of the program objectives, expected outputs, use of data products, and boundary conditions. It is not unusual that a substantial amount of time is spent in this preliminary step in order to establish the ground rules and the scope of the project in terms that everyone understands. A more complete explanation of guidance techniques used in scoping the effort is presented in Chapter 10. The following represents a brief description of the various elements of the Core QFD Matrix, with the paragraph number representing the element depicted in Figure 4-1.

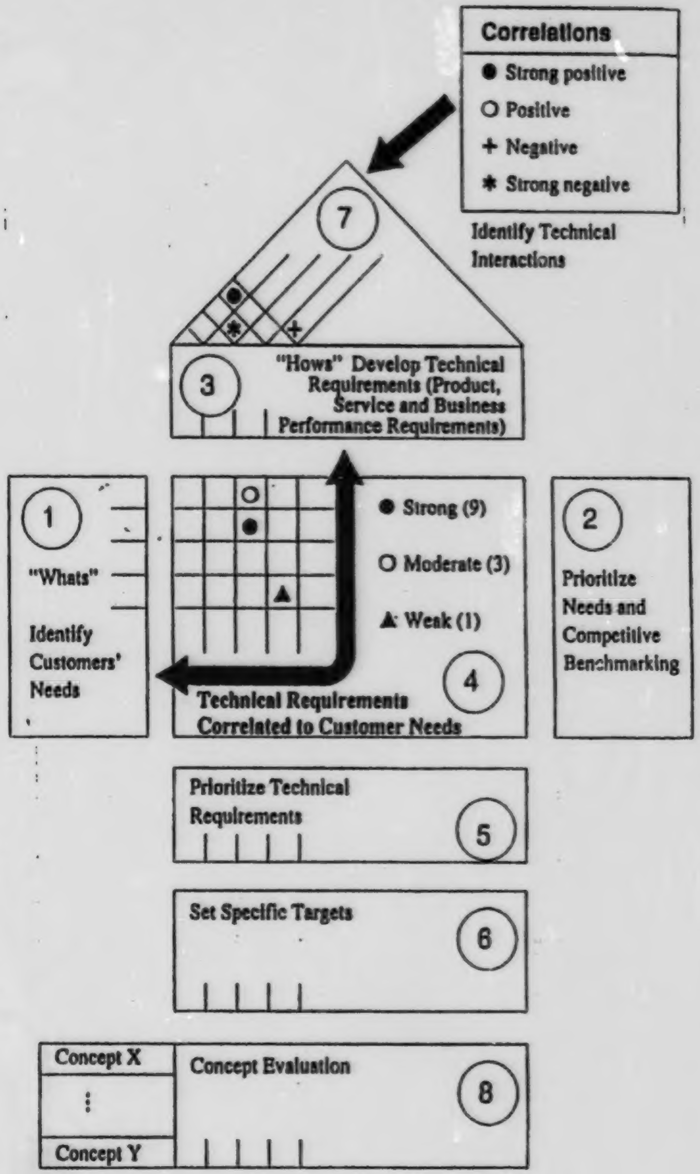

Correlations
● Strong positive
○ Positive
+ Negative
✱ Strong negative
Identify Technical Interactions
7
3
"Hows" Develop Technical Requirements (Product, Service and Business Performance Requirements)
1
"Whats"
Identify Customers' Needs
● Strong (9)
○ Moderate (3)
▲ Weak (1)
4
Technical Requirements Correlated to Customer Needs
2
Prioritize Needs and Competitive Benchmarking
Prioritize Technical Requirements
5
Set Specific Targets
6
Concept X
Concept Y
Concept Evaluation
8

Figure 4-1 The elements of the Core QFD Matrix.

1. **Identify Customer Needs** — The Core QFD Matrix begins by using the customer's physical and functional needs (sometimes termed attributes). These customer needs are often referred to as the "whats" and can be one of the most difficult elements of the matrix to construct. In some circumstances, it is difficult to get the multifunctional team to initially agree upon who is the customer, before even addressing what it is that the customer wants. Sometimes there can be multiple or primary and secondary customers. Customers can be either internal or external to the organization and their needs may be conflicting. Sometimes it is necessary to focus on who is the actual end user of the product or service in order to determine who is the final customer and resolve this conflict in order to bring a team to resolution. There are several categories of customer needs. The first category consists of explicit customer expectations. The second category involves elements a customer expects without telling you, but are soon to be part of the general requirements (e.g., environmentally compatible air conditioning coolants). The last group of customer needs includes expectations for those items not specifically requested because the customer does not know of their possible existence. These are often referred to as "excitement factors." When these features are not present people are not dissatisfied, but when they are present people are extremely pleased. The emergence of air bags and antilock brakes are good examples of excitement factors (prior to their presence because of regulation) that pleased the car-buying customer.
2. **Prioritize Needs and Conduct Competitive Benchmarking** — As mentioned above, the matrix is used to prioritize customer needs and develop competitive benchmarks. The first step in prioritization is to assume that not all customer needs can be equally important. To bring the proper perspective and focus to team activities, the Core QFD Matrix measures the relative importance to the customer of all of the defined needs. Weighted values based on customer's perceptions are derived from the team members' direct experience with the customers or from surveys. Further comparisons are made to determine where the company or project team stands relative to the competition. This is usually accomplished by comparing the customer evaluations of the competition compared to the in-house evaluations of current competitive standing.
3. **Develop Technical Requirements** — The next step involves brainstorming a list of technical characteristics or requirements that will satisfy the customer's needs. These are typically called the "hows" and should be controllable characteristics. The term "technical requirements" is used to group product, service, and operational requirements that will satisfy the customer's needs at the top level of the analysis. This is another key element of the matrix and often requires a substantial amount of time from the multifunctional team. Often one

from technical requirements. Technically-oriented individuals often immediate jump to a technical solution thinking it is a customer requirement. Therefore, it is necessary to spend substantial time in Steps 1 and 3 in order to create the most beneficial Core QFD Matrix.

4. **Correlate Technical Requirements to Customer Needs** — The "relationship matrix" indicates the impact of each technical requirement on the customer needs. A project team should seek consensus on these evaluations basing them on expert engineering or service knowledge and experience, customer responses, and tabulated data from statistical studies or controlled experiments.
5. **Prioritize Technical Requirements** — The relationship matrix can be translated into design priorities. The relational levels of importance not only define what is most important, but also define what is least important. These results provide the basis for a plan of action to implement the identified technical requirements.
6. **Set Specific Targets** — At the bottom of the Core QFD Matrix, targets are set for each corresponding characteristic to measure the process, service, or product design. If the characteristic is not measurable, then further definition is required. If a characteristic cannot be measured then there is no way to verify that it has been adequately implemented into the design, integrated into the manufacturing process, or included in the service.
7. **Identify Technical Interactions** — Measurable does not necessarily mean conflict-free. Very rarely does a system not have conflicting design elements. In a QFD matrix these correlations between the system characteristics are captured at the top of the matrix in what is traditionally referred to as the roof (hence the designation of the matrix as a "house" of quality). The distinctive roof on the Core QFD Matrix assists engineers or members of the multifunctional team in specifying various characteristic features that need to be improved collaterally. System characteristics exhibiting negative relationships are traded off to find the best compromise and strong positive relationships are studied to prevent duplication of effort. Sometimes one targeted feature impairs so many others that the team may decide to leave it alone. In complex technical designs or in providing a service based on complex information systems, ignoring this part of the matrix can result in catastrophic conflicts that were not considered in the initial stage of the design or development process.
8. **Concept Evaluation** — Product or service concepts can be evaluated against all technical requirements as related to customer needs. Each independent element of a particular concept can be evaluated for strengths and weaknesses as compared to the performance targets set during the QFD analysis. This analysis also permits the design team or the development team to determine if there are any gaps in the concept's technical solutions that would prevent meeting performance

concept to determine overall ability to meet the customer's priority needs as determined earlier in the analysis. In addition, the analysis will also yield the ability to determine if there exists a technical solution that incorporates the best of several concepts.

The above represents a brief description of the concepts involved in the eight-part Core QFD Matrix. Having been presented with the philosophy of these eight elements, the next step is to examine each individual element in more detail.

4.2 *Capturing the "voice of the customer"*

The principles found in TQM and the teachings of W. Edwards Deming (one of the premier American authorities on quality) have long advocated focusing on the customer as the key to better selling and, ultimately, increased profits. Also central to the concept of QFD is being customer-focused — but what is being customer-focused?

QFD relies upon the principle of listening to the "voice of the customer" which is a term that is often used when describing what the customer desires from a product or service. Finding out what the customer wants is an industry in itself, and QFD relies on accurate information on the customer. However, before defining what it is the customer wants, one must first define who is the customer, and that depends on the scope or goals of the QFD analysis itself.

Figure 4-2 illustrates a stepped approach for organizing the effort to determine the "voice of the customer." Primary to the stepped approach is organizing the efforts of the QFD study and establishing the team. Team selection is always difficult in any situation, and often the success of a program relies heavily on the composition of the team. In general, a multifunctional team that can address all of the functions and departments that may be impacted by the QFD analysis needs to be assembled (Chapter 10 discusses how to assemble the skills necessary to address a QFD analysis). This does not mean that a team will have a representative from each department. Individuals who can interface with several departments or skill areas may satisfy the requirement.

The success of a QFD study also relies upon a clearly focused goal. For example, a QFD can be a laborious and tedious process, and if the team members are new to the QFD philosophy it may be prudent to design a QFD initial effort. This effort should last 3 to 4 days and be devoted to team building and establishing the top-level Core QFD Matrix for the new product or service. A team leader or program manager should have in mind what is expected out of the QFD prior to the start of the study. If the QFD is only to establish top-level systems requirements in response to customer needs, that effort should be explained clearly and succinctly to the team members so they do not misunderstand the goals of the effort. The authors have worked with companies where QFD had been attempted earlier but failed because the effort bogged down in details and technical minutiae that prevented the creation of a systems or overall Core QFD Matrix (Chapter 10 discusses methodologies for defining the scope of the QFD and conducting team selection).

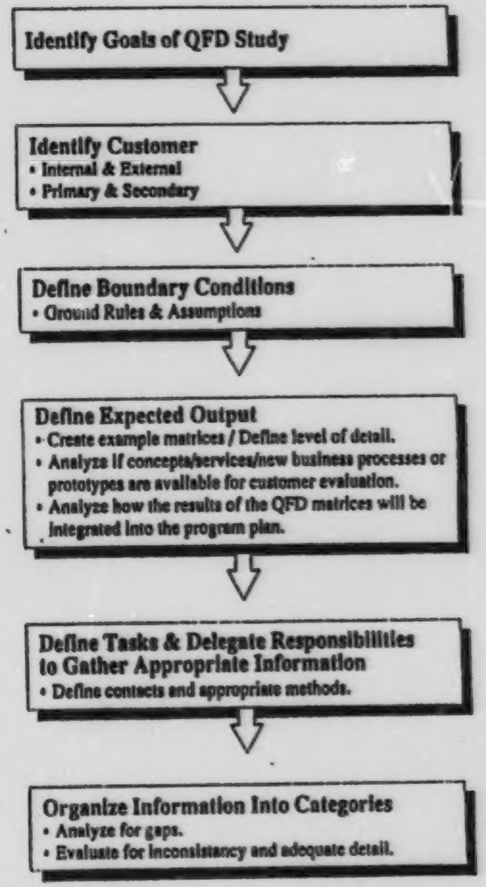
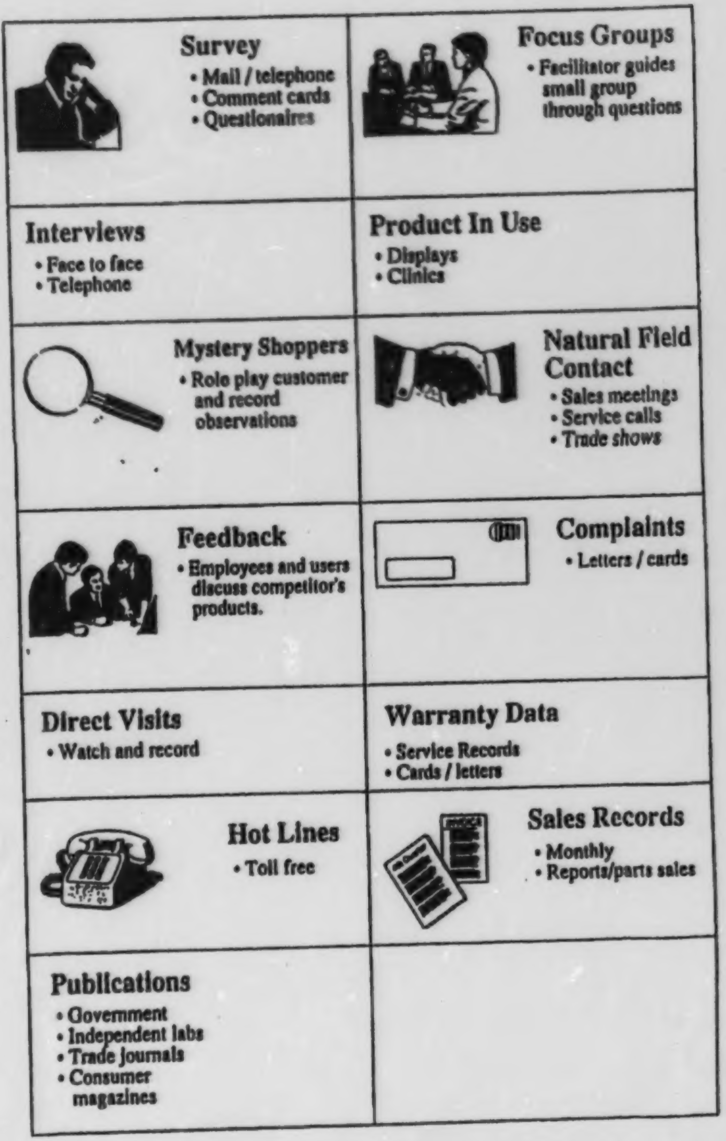

Identify Goals of QFD Study
Identify Customer
• Internal & External
• Primary & Secondary
Define Boundary Conditions
• Ground Rules & Assumptions
Define Expected Output
• Create example matrices / Define level of detail.
• Analyze if concepts/services/new business processes or prototypes are available for customer evaluation.
• Analyze how the results of the QFD matrices will be integrated into the program plan.
Define Tasks & Delegate Responsibilities to Gather Appropriate Information
• Define contacts and appropriate methods.
Organize Information Into Categories
• Analyze for gaps.
• Evaluate for inconsistancy and adequate detail.

Figure 4-2 Steps to the "voice of the customer."

Once the goals of the QFD analysis have been established, the next step is to select the customer or customers. Customers can be internal and external. Internal customers can be other departments, other divisions of a company, or other individuals in the organization who make use of information, products or services produced by other internal sources. Prior to engaging in the QFD process, the team must first determine who the customers are, both internal and external. This is a very critical step in the process because it will drive the gathering of information to determine the needs of the customer or customers. In the process of examining this question, most teams soon realize that there is more than a single customer. For example, in developing a new computer component piece, the component manufacturer may realize there are several customers: the ultimate customer will be the consumer who will use the assembled computer; another key customer will be the computer integrator who is building the entire product, who may have certain technical needs of the component that are irrelevant to the ultimate user (the consumer); there can also be a third-tier customer, who is internal to the component manufacturer, e.g., a manufacturing department may need certain processes identified in advance in order to prepare the manufacturing process and meet the scheduled delivery date. Based on considerations such as these, it may be important to group or segment customers according to certain similarities. Once this has been done, a primary Core QFD Matrix can be designed to determine the needs of the primary customer and then secondary matrices can be constructed to determine whether or not there are any additional customer needs to be met, or if there are conflicting requirements for any two customers.

Once the customer, or customers, have been identified it becomes necessary to create a structure for determining the customer needs. This structure identifies the boundary conditions for gathering information on customer needs. Part of defining the boundary conditions includes budget available for developing customer information, time limitations, assumptions that need to be made about the customer, and resources that are available to all members of the team. In addition, the type and extent of customer information to be gathered must be defined. For example, there are many techniques for gathering information on customer needs and desires in a product. Some of those techniques are listed in Figure 4-3. Typically, most organizations employ their marketing departments, or an outside marketing and information gathering agency. These groups define how to gather information on both customer needs or desires for a new or existing product and potential competitive benchmarking for any other products or services that may already exist. Figure 4-3 is not meant to represent an exhaustive list of potential marketing and information gathering techniques, but instead to give some guidance in scoping the gathering of information for a new product or service. The resources available to conduct marketing research and gather information must always be considered and bear a relationship to the risk for the new product or service and its potential for profit. Often the first task for a product or service team will be to determine if enough data already exists to do a preliminary QFD analysis mapping the customer needs against technical requirements. This is a difficult decision to make because often it is not known that certain data or information regarding customer needs is missing until the initial top-level QFD is completed, or at least attempted. There is no hard-and-fast rule that states once a QFD analysis is started the team cannot



Survey • Mail / telephone • Comment cards • Questionaires	**Focus Groups** • Facilitator guides small group through questions
Interviews • Face to face • Telephone	**Product In Use** • Displays • Clinics
Mystery Shoppers • Role play customer and record observations	**Natural Field Contact** • Sales meetings • Service calls • Trade shows
Feedback • Employees and users discuss competitor's products.	**Complaints** • Letters / cards
Direct Visits • Watch and record	**Warranty Data** • Service Records • Cards / letters
Hot Lines • Toll free	**Sales Records** • Monthly • Reports/parts sales
Publications • Government • Independent labs • Trade journals • Consumer magazines	

Figure 4-3 Techniques for obtaining new information.

stop to conduct additional data gathering in order to ensure that the customer needs are truly identified and are being incorporated into the design or service development process. It is incumbent upon the team to determine how the data is going to be gathered, what techniques will be used, who will gather the data, and finally how the data will be analyzed.

In facilitating a QFD effort, the initial brainstorming to determine who the customers are and what data or information needs to be gathered can serve a dual purpose. First, it gives direction to the team. Second, this process can easily lend itself to the initial team-building effort and break down some of the barriers that may exist between disparate functions or departments in a company. Sometimes these conflicts develop because of a lack of communication and contact, or because the individuals from the departments may never have had the need to work together in a team environment (Chapter 10 discusses additional ways to not only select the team, but also to develop team cohesiveness in the initial phases of the QFD process).

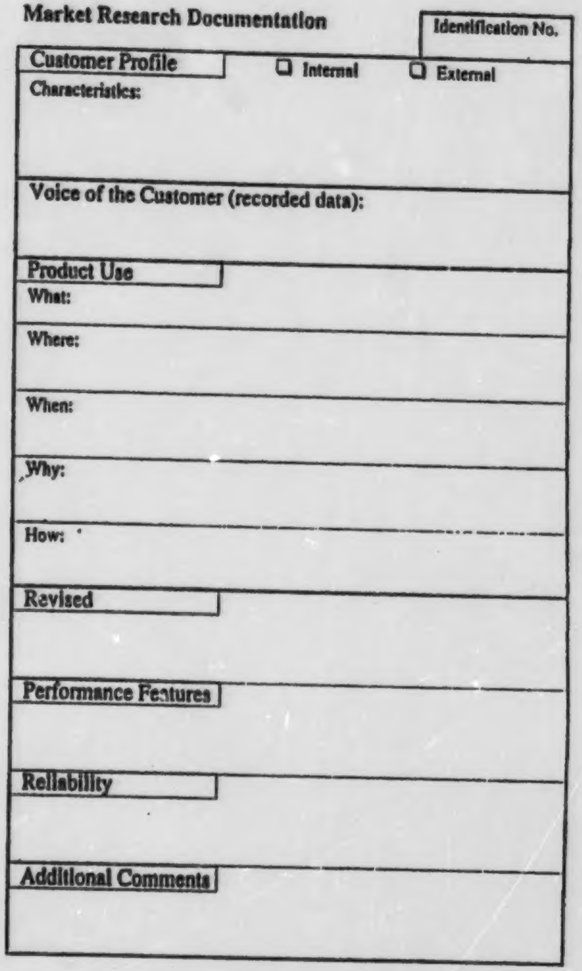
Although there is a substantial amount of information available in existing literature on gathering customer-related data, the authors have included Figures 4-4 and 4-5 as examples of how to document market research information, and guidelines for survey and interview questions. Figure 4-4 is a blank sample marketing research document and Figure 4-5 is a completed form using some data of a potential customer for our imaginary video game company, Compulsive Video Mania.

An organization may wish to enlist the services of a professional market research firm to conduct focus groups, detailed and focused customer surveys, or other tools either before or during the QFD effort. In the process of analyzing the customer information the team should look for gaps or inconsistencies in the information.

The authors have found that this stage of the QFD process is often overlooked because some organizations think they are in tune with the customers' needs if they currently are in a profitable position or they have conducted past marketing research. This is where a multifunctional team conducting its own analysis of existing data or looking at a new product design may determine that there are either information gaps or outdated assumptions on what customers really want or need. Marketing and business history is full of examples of misdiagnosing the pulse of the customer. The Edsel is a classic example, but recent times have also seen failures of greater magnitude such as Coca-Cola introducing "New Coke" in 1985 — the return of "Classic Coke" did not take very long!

The important point in addressing the "voice of the customer" is to fully understand the needs of the customer, and that is often best done by asking the customer directly. This is why more and more companies are bringing the customer into the design and development process and making the customer part of the multifunctional and multidisciplined team.

Once the above groundwork has been done, the next step is to begin constructing the Core QFD Matrix.



Market Research Documentation

Identification No.

Customer Profile ☐ Internal ☐ External

Characteristics:

Voice of the Customer (recorded data):

Product Use

What:

Where:

When:

Why:

How:

Revised

Performance Features

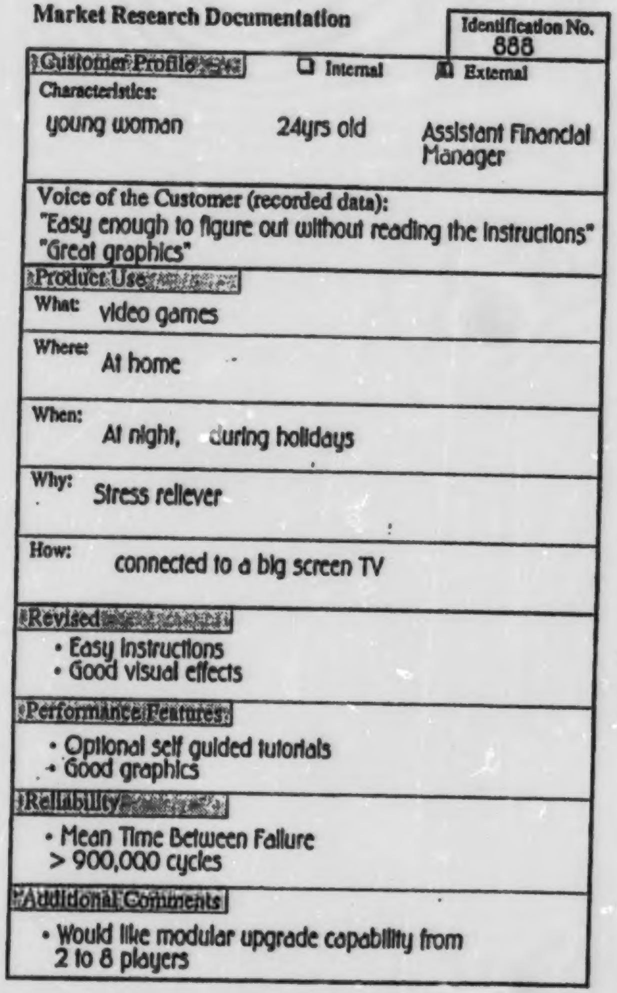
Reliability

Additional Comments

Figure 4-4 The Market Research Document.

4.3 Constructing a Core QFD Matrix

The Core QFD Matrix represents the information gathered and the decisions determined by the product or service team in the QFD process. The Core QFD Matrix is a very compressed and compact mosaic of information compiled, discussed, argued over, fought over, and finally compromised on by the team. In implementing a QFD effort, many questions arise as to how the information gathered and developed by the team gets translated into the



Market Research Documentation

Identification No. 888

Customer Profile

☐ Internal ☒ External

Characteristics:

young woman 24yrs old Assistant Financial Manager

Voice of the Customer (recorded data):
"Easy enough to figure out without reading the instructions"
"Great graphics"

Product Use

What: video games

Where: At home

When: At night, during holidays

Why: Stress reliever

How: connected to a big screen TV

Revised

- Easy instructions
- Good visual effects

Performance Features

- Optional self guided tutorials
- Good graphics

Reliability

- Mean Time Between Failure > 900,000 cycles

Additional Comments

- Would like modular upgrade capability from 2 to 8 players

Figure 4-5 Video game example of the Market Research Document.

format represented by the matrix. Where do the customer needs come from? How does the team come up with the technical requirements?

One of the most effective ways to understand the operation of the Core QFD Matrix is to walk through a specific example for each of the various elements. We will use the development of a video game by our imaginary company Compulsive Video Mania (CVM) to illustrate not only the mechanical functions of the Core QFD Matrix, but also the conceptual relationship of the elements. Most of us, either through personal or vicarious experience

through our children, have had some exposure to the video game craze that has swept the country. Without debating the merits of the pastime, video games offer an excellent example of a product that is fairly technical in nature, but also reaches a mass audience in an industry that is highly competitive and constantly changing. The president of the company has selected key team members from the following departments: marketing, design, software, hardware, procurement, human factors, test, manufacturing, subcontracts and finance to construct the next generation of video games. The team has decided to use the QFD process in an effort to get the jump on the other video game manufacturers. The QFD team first determined through its marketing that its customer would be 8-year-olds to adults who currently owned some variety of video game equipment. Although this was a fairly wide demographic group, the team decided that it may later conduct additional QFDs to target certain age groups or demographic groups within that bracket. The team also determined that its secondary customer might be the manufacturers of the QFD game players. These were secondary customers because CVM had to be able manufacture games that would play on the various video game equipment currently on the market.

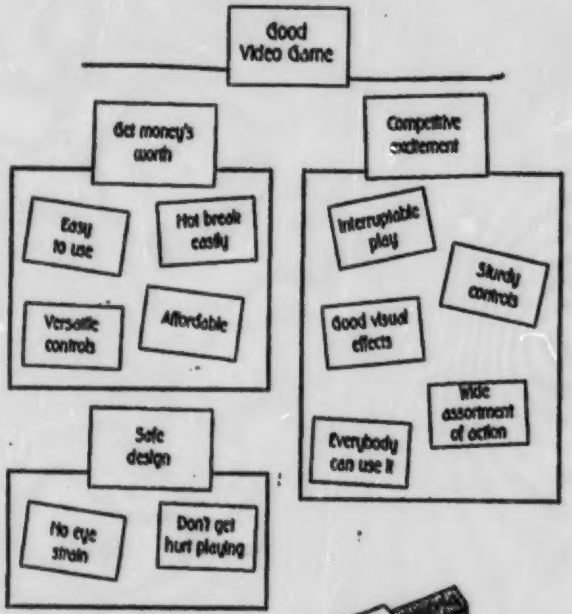
4.3.1 Techniques to support the development of a Core QFD Matrix

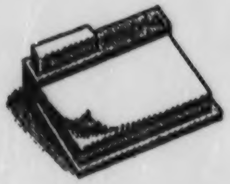
There are three analytical tools that can be utilized effectively both in the initial stages of the QFD and in later stages of full integrated product development. These three tools are (1) brainstorming, (2) affinity diagramming, and (3) tree diagramming.

In determining the initial customer needs it is helpful to use a technique called "brainstorming" that creates an open environment for creativity and taps the individual resources of all the team members. When determining the initial customer needs, the group should list all attributes including those determined by any form of market research and perceived or suspected attributes demanded by the customer in the new product or service (tips on the technique of brainstorming are contained in Chapter 10).

Once the customer needs have been brainstormed, it is often extremely helpful — especially given the fact that there are often a large number of customer needs or attributes identified — to group the customer needs through the use of affinity diagramming. Using our imaginary video game company, CVM, Figure 4-6 illustrates how affinity diagramming is used to develop some of the customer needs for the new video game. As the reader can see, certain attributes of the video game can be grouped into elements that have an "affinity" for each other, or objects that are at least similar in their purpose or function. Affinity diagramming also assists the team in eliminating duplicate needs of the customer.

The next tool that can be used is tree diagramming. Figure 4-7 gives an example of the information contained in Figure 4-6 but arranged in a tree


Good Video Game
Get money's worth
Easy to use
Not break easily
Versatile controls
Affordable
Competitive excitement
Interruptable play
Sturdy controls
Good visual effects
Wide assortment of action
Everybody can use it
Safe design
No eye strain
Don't get hurt playing



Construction Guidelines

1) Record data on Post-It™ notes.

2) Place on board.

3) Organize information into similar groups without talking.

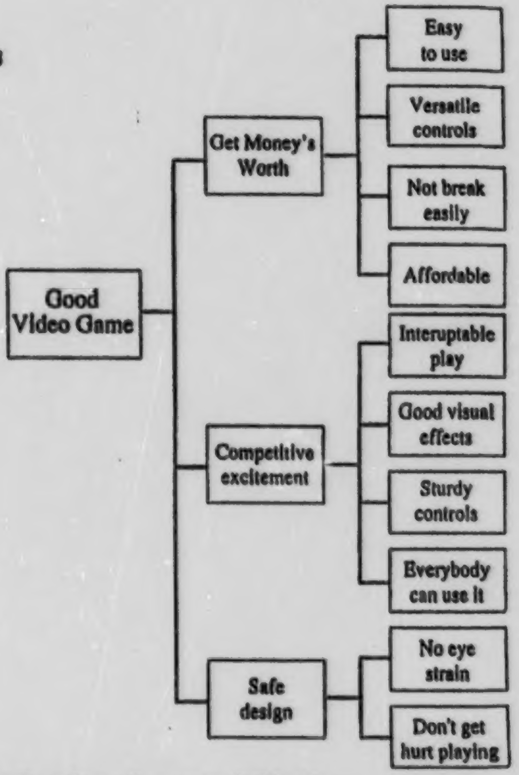
5) Establish a summary title for each group.

6) Critically evaluate each group:
Remove "Hows" from "Whats" categories.
Eliminate redundancy.

Figure 4-6 Affinity Diagrams using the development of a video game as an example.

diagram. The purpose of the tree diagram is to create a complete list of requirements or objectives but in a more categorical manner than simple affinity diagramming. Essentially the individual elements of a tree diagram can be traced back to a central grouping or concept idea, like the branches of a tree lead back to the trunk. Tree diagramming also allows the visual creation of relationships at various detail levels and can help the group to determine if, in the initial Core QFD Matrix creation, they want to go down to the lowest level of detail, or tackle the matrix at a higher level of grouping. The tree diagram can also reveal any gaps or holes in the sequence or logic in the grouping itself, or in the determination of the customer needs.

Tree Diagrams


Good Video Game
Get Money's Worth
Easy to use
Versatile controls
Not break easily
Affordable
Competitive excitement
Interuptable play
Good visual effects
Sturdy controls
Everybody can use it
Safe design
No eye strain
Don't get hurt playing

Purpose:

Create complete list of requirements / objectives

Construction Guidelines:

1) Translate the Affinity Diagrams into a hierarchy.

2) Start hierarchy on left side of chart.

3) Place more detailed items in secondary levels or tertiary levels depending on relationship.

4) Establish and record definitions of categories as necessary.

5) Examine tree for gaps and consistency in detail between levels.

Figure 4-7 Tree Diagrams using the development of a video game as an example.

4.3.2 *Developing the detailed Core QFD Matrix*

The eight elements of the Core QFD Matrix can be further divided into some subelements for purposes of calculating the mathematical relationships between the various customer needs and technical solutions. Figure 4-8 refers to each of the eight sections and subelements using numbers and letters for easy reference in this chapter. By understanding how to create the core QFD Matrix, the reader will have the understanding to develop the four Matrices in the Integrated QFD Approach™ that were introduced in Chapter 3 (Figure 3-8), and are analyzed in detail in Chapter 7.

The subelements of the Core QFD Matrix are not fixed constants impervious to alteration. As the reader becomes more familiar with the structure and logic behind each element of the matrix, the possibilities of adapting some of the subelements and calculations to specific situations should become apparent. The Core QFD Matrix is just that — a core to be added to or modified as required by circumstances.

The following describes how the matrix is completed and from where the information comes. Some facilitation hints are given based on actual situations. However, Chapter 10 discusses in more detail how to facilitate these sections more effectively. The reader should approach the following material with an eye for understanding the mechanics of generating the information for each of the eight sections of the Core QFD Matrix. Appendix A provides a quick reference guide to performing the mechanics of the Core QFD Matrix.

4.3.2.1 *Determining the customer needs (Section 1)*

The customer needs section contains the information gathered by the team to represent the key elements the customer wants. After brainstorming and using affinity and tree diagrams, the CVM team came up with the customer needs contained in Figure 4-9. The team placed in Section 1 of the matrix the three basic attributes that the video game needed to meet: (1) get money's worth, (2) provide competitive excitement, and (3) safe design. These needs were then broken down into subcategories on the left side of the matrix. Having defined their initial customer needs, the next step for the team was the second element of the Core QFD Matrix: prioritizing the customer needs and doing competitive benchmarking.

4.3.2.2 *Prioritizing customer needs and competitive benchmarking (Section 2)*

The next task for the project team was to prioritize the importance to the customer of the identified needs, and do competitive benchmarking against two of Compulsive Video Mania's competitors. Section 2 of the QFD matrix is divided into nine subsections, represented in 2A through 2I below and in Figure 4-10.

2A. Degree of Importance — The first step in prioritizing needs is represented by 2A-Figure 4-10. Column 2A is the relative degree of importance of each of the customer needs. The question being answered by the

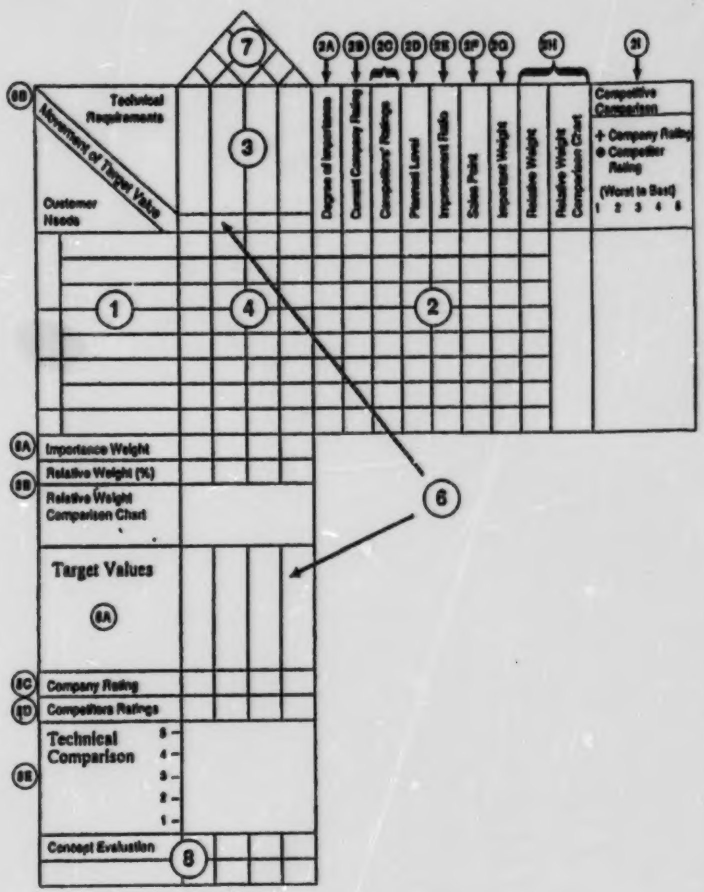

7
2A
2B
2C
2D
2E
2F
2G
2H
2I
6B
Technical Requirements
Movement of Target Value
Customer Needs
3
Degree of Importance
Current Company Rating
Competitors' Ratings
Planned Level
Improvement Ratio
Sales Point
Important Weight
Relative Weight
Relative Weight Comparison Chart
Competitive Comparison
+ Company Rating
● Competitor Rating
(Worst to Best)
1 2 3 4 5
1
4
2
6
5A
Importance Weight
Relative Weight (%)
5B
Relative Weight Comparison Chart
Target Values
6A
5C
Company Rating
5D
Competitors Ratings
Technical Comparison
5E
5
4
3
2
1
Concept Evaluation
8

Figure 4-8 Detailed Core QFD Matrix guide.

is 1 to 5, with 5 being the most important. When ranking the customer needs, the team first determined which of the customer needs would be *the* most important. As you can see, the range of ranking went from 2 for "versatile controls" and "interruptable play" to the most important elements (5) that were "wide assortment of action" and "good visual effects."

When ranking the degree of importance, it is not as important to have a range of customer needs ranked 1 to 5, as it is to have directed discussion to truly determine which of the customer needs ranks the highest and which are not so important in the total scheme of customer needs. One way to determine this relative ranking is to ask the team what they would give up among

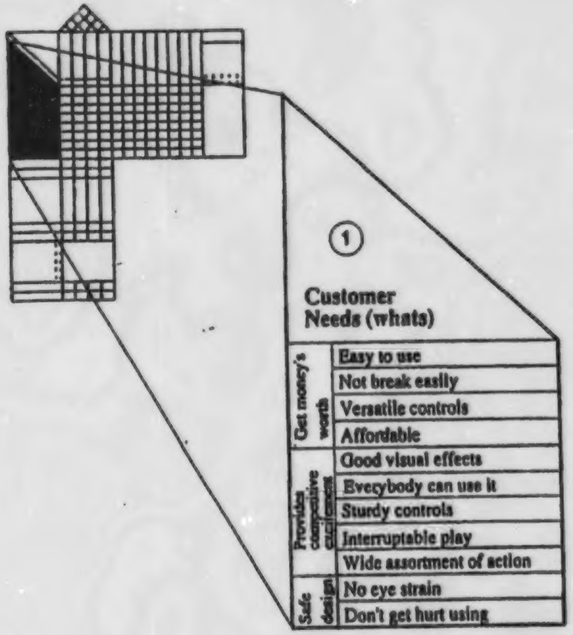
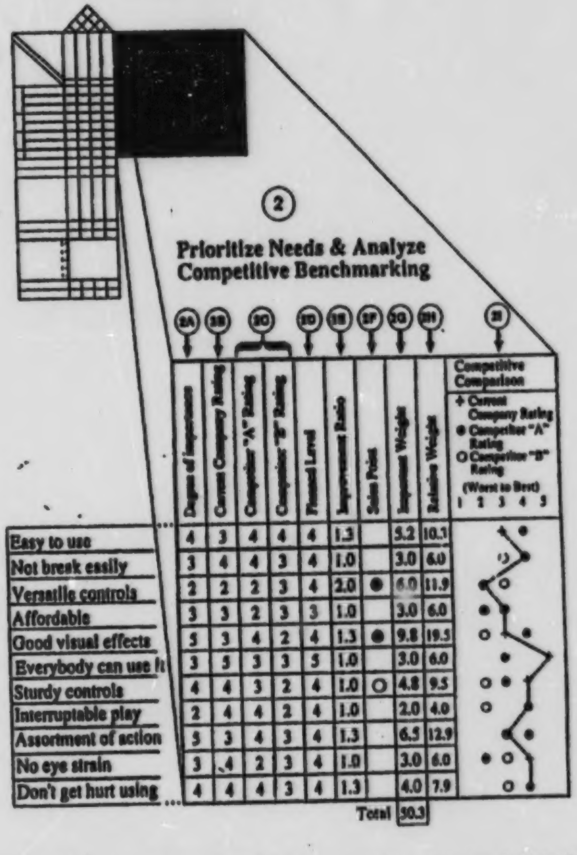

①
Customer Needs (whats)
Get money's worth
Easy to use
Not break easily
Versatile controls
Affordable
Provides competitive excitement
Good visual effects
Everybody can use it
Sturdy controls
Interruptable play
Wide assortment of action
Safe design
No eye strain
Don't get hurt using

Figure 4-9 Video game Core QFD Matrix example — Section 1: Identify Customer Needs.

technique is to ask the customer, if present, what is most important. Sometimes customers feel overwhelmed and outnumbered by the team members and do not voluntarily discuss their preferences, and failure to bring them into the discussion can lead to catastrophic failure. One of the authors was involved in a QFD with the customer present, where the focus of the QFD was to map into the QFD matrix the specifications originally given by the customer. At the end of the day and after a grueling amount of work, the customer pulled the author aside and said, "You know, I really do not want what's in there (the QFD) — What should I do?" The author offered to intervene and let him talk specifically to the team to describe his idea of the customer needs. After describing eight mission goals to the team, he said that what he wanted was for the team to tell him what kind of performance was required for these goals, and what kind of system concepts would meet those needs within the proposed budget. The next day the group started again, but the QFD facilitator (not the author) ignored the customer's request stating that if it was not in the "specs" it was not a real need. The team finished the original QFD and lost the contract.

2B. Current Company Rating — The next step is to fill in Column 2B which ranks the company's performance or ability to meet this current need. The question being answered here is: "How well do you think your company


②
Prioritize Needs & Analyze Competitive Benchmarking
2A
2B
2C
2D
2E
2F
2G
2H
2I
Competitive Comparison
+ Current Company Rating
● Competitor "A" Rating
○ Competitor "B" Rating
(Worst to Best)
1 2 3 4 5

	Degree of Importance	Current Company Rating	Competitor "A" Rating	Competitor "B" Rating	Planned Level	Improvement Ratio	Sales Point	Importance Weight	Relative Weight
Easy to use	4	3	4	4	4	1.3		5.2	10.1
Not break easily	3	4	4	3	4	1.0		3.0	6.0
Versatile controls	2	2	2	3	4	2.0	●	6.0	11.9
Affordable	3	3	2	3	3	1.0		3.0	6.0
Good visual effects	5	3	4	2	4	1.3	●	9.8	19.5
Everybody can use it	3	5	3	3	5	1.0		3.0	6.0
Sturdy controls	4	4	3	2	4	1.0	○	4.8	9.5
Interruptable play	2	4	4	2	4	1.0		2.0	4.0
Assortment of action	5	3	4	3	4	1.3		6.5	12.9
No eye strain	3	4	2	3	4	1.0		3.0	6.0
Don't get hurt using	4	4	4	3	4	1.3		4.0	7.9
							Total	50.3	

Figure 4-10 Video game Core QFD Matrix example — Section 2: Prioritize Needs and Analyze Competitive Benchmarking.

meets this need?" Again, a 1 to 5 ranking is utilized, with 5 indicating that the company fully meets that customer need at this time and that there is no room for improvement. The CVM team has ranked their company's ability to meet the identified customer needs. This can be done in a variety of ways, including third-party interviews and marketing analysis. A 5 would indicate that the company is completely meeting a need and improvement would be difficult.

2C. Competitors Rating — The next step, which also deals with benchmarking as does Column 2B, is Column 2C: competitors rating. The question that needs to be answered here is: "How well do you think your best competitors meet this need?" This is often one of the most difficult columns to complete in the total scheme of needs ranking and benchmarking. Often it is difficult to determine, first of all, who is a competitor in a particular field and if that competitor currently performs to a certain level of expertise regarding that particular customer need. This is where research and market data gathering can be the most beneficial. CVM compares favorably in most categories to its competition, Competitor "A" and Competitor "B." Because markets are changing so quickly, it often makes sense to analyze the competition at a point projected in the near future. The question to be answered then becomes: "How well do you think your *best* competitor will meet this need by the time you launch this new product, service, or business operation?"

2D. Planned Level — After completing the ratings for competitors, the next step of competitive assessment and benchmarking is to determine the planned level (Column 2D) for your organization. The question the team must answer is: "By the time you launch this new product, service, or business operation, where would you like your company to be relative to today?" Compulsive Video Mania determined that they wanted to increase their ability to meet their customers' needs by one to two steps for every element identified. This step of the competitive assessment can also be difficult because often, at this stage of the development of the QFD matrix, it is difficult to determine not only where the company may be in terms of benchmarking these elements, but whether or not the company can improve in certain areas. One effective way to look at this measurement is to determine where the company should be in order to *stay* competitive in the market regarding the planned level. Therefore, the second question to be answered by the team is: "Do you have or should you get the resources to make this improvement, taking into account how important this need is to the customer and how well your competitors provide this need?" In other words, Compulsive Video Mania determined that they currently have games that are easy to use and that no competitor outshines them in this area. Therefore they would like to remain at the planned level of 4. As with the other measurements in this section, it is important to look at these numbers as a comparative weighting among all the customer needs. It is important to identify exactly what a "4" means in terms of level. If a company assesses itself as being very good in that particular customer need at this time, or if the company assesses itself as needing improvement in that particular customer need, the definition of what is a "4" is often based upon marketing research and data taken.

2E. Improvement Ratio — The next step in filling out the Core QFD Matrix is to determine the improvement ratio (Column 2E), which is simply taking the planned level for that particular customer need and dividing it by the current company rating (2D divided by 2B). This ratio gives a weighted value for those customer needs that would require the most improvement. For example, Compulsive Video Mania feels that they currently perform at a level of "2" for versatile controls, but they feel that it is necessary for their new product to attain a planned level of "4" in their versatility. This would make the improvement ratio 4 (Column 2D) divided by 2 (Column 2B) which equals 2.

2F. Sales Point — Having determined the improvement ratio, the next step is to determine if any of the customer needs, when met, would give a competitive advantage to Compulsive Video Mania. This column is represented by the sales point (Column 2F). Not all elements are sales points. As mentioned earlier, a sales point is often a feature that the customer may not think is needed, but if it were provided it would create the "wow" factor. In other words if the customer saw this feature, perhaps not even anticipating it, the response would be "wow!" Sales points can be divided into three areas: (1) a big advantage which is worth 1.5 (represented by a filled circle), (2) a slight competitive advantage which is equal to 1.2 (represented by an open circle), or (3) no competitive advantage at all which is equal to 1 (represented by no symbol). As a rule of thumb, with a matrix consisting of approximately ten to fifteen customer needs, there should be no more than one, or possibly two, sales points that give a big advantage, and one or two sales points that provide a slight advantage. These are represented on the QFD matrix as symbols for a quick visual assessment of which elements provide sales points.

2G. Importance Weight (Customer Needs) — The next step is to determine the importance weight of the customer needs. This is represented in Column 2G and is calculated by multiplying the value of Column 2A (Degree of Importance) times Column 2E (Improvement Ratio) times Column 2F (Sales Point) of each customer need. This calculation takes the three most important elements and multiplies them for a final weight.

2H. Relative Weight (Customer Needs) — The next step is to normalize the importance weights in Column 2G as represented in Column 2H, the relative weight. This is done by taking the sum of the total of Column 2G and using it as a denominator for each value in Column 2G and then multiplying each column by 100 to normalize it. For example, in the QFD matrix created by Compulsive Video Mania, the total of Column 2G equals 50.3. The relative weight for the customer need of "easy to use" is then calculated as follows: (Value of 2G divided by a total of Column 2G) times 100, which is numerically represented as (5.2 divided by 50.3) times 100, which equals 10.3. This relative weight is then used in prioritizing technical solutions, as will be illustrated below. Often the relative weight is graphically represented in a bar chart for quick visualization of driving customer needs.

2I. Competitive Comparison Chart — The last task in Section 2, represented by 2I, is the graphical representation of columns 2B and 2C, Current Company rating and Competitors Rating, respectively. This step is not essential in the creation of the matrix, but permits two analyses: (1) The graphical representation gives a quick view of how your company compares to its competitors in meeting the customer needs; and (2) When later taken in comparison with Section 5 (which graphically portrays how you and your competition compare in meeting technical requirements) is a double-check to see if marketing and engineering or the requirements departments are in step in evaluation of technical and customer needs.

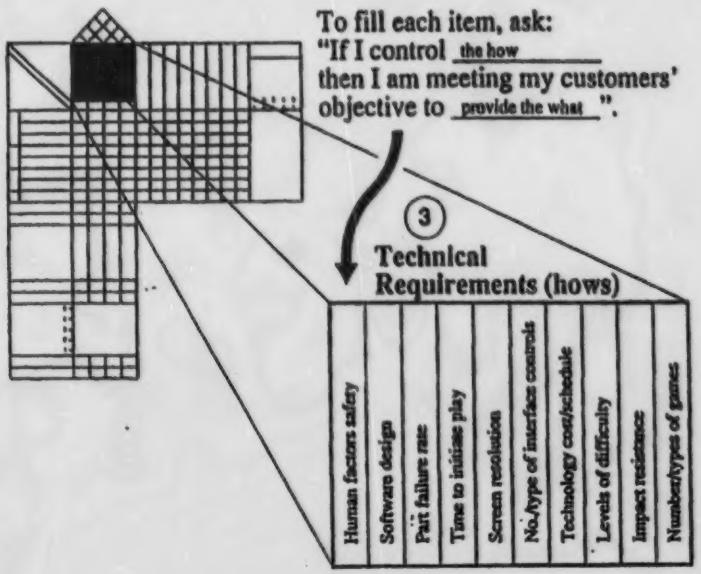


Figure 4-11 Video game Core QFD Matrix example — Section 3: Develop Technical Requirements (products, services, or business performance requirements).

4.3.2.3 *Develop technical requirements (Section 3)*

Technical requirements for meeting the customer needs can be developed in a manner similar to that used to develop the customer needs themselves (see Figure 4-11). The question the team should be answering is: "What can I control that allows me to meet my customers' objectives?" For example, "If I control the *number and types of games* then I am meeting my customers' need to have a wide assortment of action." Brainstorming and affinity diagramming can be combined with marketing knowledge to determine levels of technical detail. In other words, the following factors should be taken into consideration and used when developing the technical requirements:

- Use the "If I control . . . " question to help determine technical requirements;
- Use existing data and the combined experience from team members;
- Collect all available technical data from sources such as:
  - Statements of work/requests for proposals
  - Related publications
  - Technical interchanges with the customer
- Use brainstorming to identify any additional requirements;
- Use affinity/tree diagrams to organize the information;
- Additional guidelines:

- Address top-level requirements initially (such as systems before subsystems);
- Identify performance parameters;
- More detailed technical solutions are not necessarily better;
- Avoid restating components of particular products, services, or organizations;
- At the initial level try not to include parts or mechanisms, but focus on systems or technical solutions;
- Establish definitions for the technical solutions that are understood by all team members.

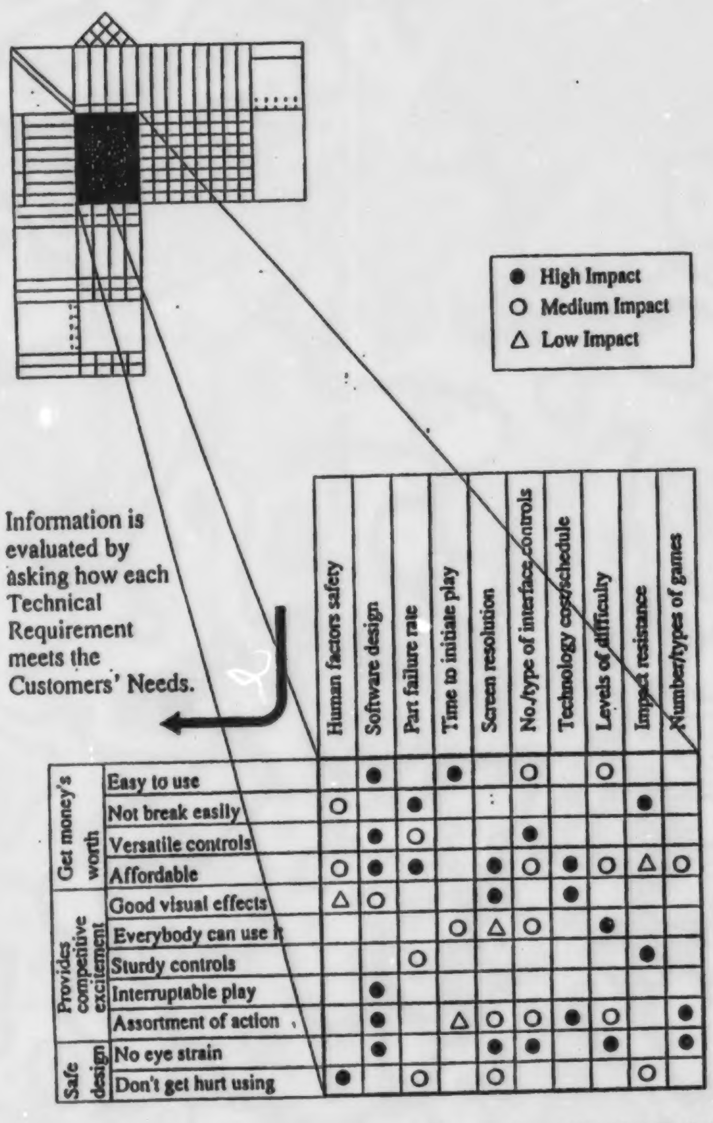
For Compulsive Video Mania, the technical requirements are listed across the top of the Core QFD Matrix. These technical requirements focus on product requirements and do not take into consideration the service and business operation elements as a result of the original scoping of the QFD project by the team. In addition to the standard technical requirements, there may also be special requirements such as government requirements, company policies, or other compliance-related requirements. For example, in the environmental industry there are often government agency requirements that must be met when considering design solutions.

4.3.2.4 *Correlating technical requirements to customer needs (Section 4)*

Section 4 of the initial matrix as represented by Figure 4-12 is the relationship area of the Core QFD Matrix. In this section, technical requirements are correlated to individual customer needs to determine strength of relationship and impact on the need. These relationships are numerically represented in Section 4. In order to determine the strength of a technical requirement to satisfy a customer need, four measures are utilized:

- *Strong relationship*, which has a numerical value of nine and is represented by a filled circle;
- *Moderate relationship*, which has a numerical value of three and is represented by an open circle;
- *Weak relationship*, which has a numerical value of one and is represented by a triangle; and
- *No relationship*, in which case the cell is left blank.

The three symbols representing the various degrees of relationship are allegedly derived from the Japanese horse betting system, with a strong relationship (a filled circle) equating to a "win," a moderate relationship (represented by an open circle) meaning "place," and a weak relationship (the triangle), equalling a "show." This horse racing analogy is also useful when facilitating the creation of a QFD matrix. It is often easier to rank correlations if the team considers whether or not the technical requirement is a "winner" for meeting the particular customer need.


Information is evaluated by asking how each Technical Requirement meets the Customers' Needs.
● High Impact
○ Medium Impact
△ Low Impact

		Human factors safety	Software design	Part failure rate	Time to initiate play	Screen resolution	No./type of interface controls	Technology cost/schedule	Levels of difficulty	Impact resistance	Number/types of games
Get money's worth	Easy to use		●		●		○		○		
	Not break easily	○		●						●	
	Versatile controls		●	○			●				
	Affordable	○	●	●		●	○	●	○	△	○
Provides competitive excitement	Good visual effects	△	○			●		●			
	Everybody can use it				○	△	○		●		
	Sturdy controls			○						●	
	Interruptable play		●								
	Assortment of action		●		△	○	○	●	○		●
Safe design	No eye strain		●			●	●		●		●
	Don't get hurt using	●		○		○				○	

Figure 4-12 Video game Core QFD Matrix example — Section 4: Correlate Technical

Another important tool in the team's evaluation process for correlating technical requirements and customer needs is to use the following sentence:

> If I control (the technical requirement) it will (significantly/moderately/slightly/or not) impact my customers' needs to (insert specific customer need).

This approach allows the team to determine whether or not the technical requirement correlates to a specific customer need. For example, in Figure 4-12 the technical solution of "software design" (Column 2) when compared to the first customer requirement of "easy to use" would be done as follows:

> If I control software design it will *significantly* impact my customers' need to make it easy to use.

and conversely,

> If I control the screen resolution it will *not* impact my customers' objective to make it easy to use.

The corresponding cell has no correlation in it because the technical requirement of screen resolution would not affect the ability to have the game easy to use. However, the technical requirement "time to initiate play" (Column 4 in Figure 4-12) would very definitely have a strong or "winning" effect on instructions being easy to use. Therefore, a filled circle is placed in that particular cell.

The selection of the numerical values 9/3/1/blank is a relative weighting so that strong correlations are valued heavily while correlations that are nonexistent or weak carry little value. Some users of QFD have substituted other values for the 9/3/1/blank system such as 5/3/1/0 and 4/2/1/0 for strong/moderate/weak/no relationship. The Japanese prefer the 4/2/1/0 or the 5/3/1/0 numerical values. The authors believe the 9/3/1/blank system better identifies drivers to the system and causes less arguments over distinctions that may not really matter, as well as providing greater separation between the technical solutions; this highlights the critical issues. Through sensitivity analyses the authors have discovered that the relative prioritization of technical solutions does not change significantly with any of the above numeric schemes. When facilitating a team through a QFD exercise, it is often important to spend a lot of time discussing a 9 vs. a 3 or a 1 relationship, but spend little time discerning between a 3 relationship and a 1 relationship, because of the lesser overall significance.

The symbols are used so that a visual examination of the chart can yield a quick evaluation of important technical requirements and important customer needs. In addition, evaluation of this section of the matrix, if done in either technical requirements to meet customer needs, or perceived technical requirements that do not add or correlate to any customer needs. This can be determined as follows: if a row for a customer need is blank or perhaps has only a single correlation among the technical requirements, the team may re-examine this customer need to first determine whether or not it is a real customer need and secondly whether or not there are any technical requirements that would meet that customer need. Similarly, any columns of technical requirements that are blank indicate either a technical requirement that fulfills no customer needs, or, possibly, a perceived need for a technical requirement but the customer need has not been properly identified.

In this way, Section 4 of the Core QFD Matrix operates in two ways: (1) as a mechanism to *correlate* customer needs and technical requirements, and (2) as a mechanism to *reevaluate* or check the results of selecting the requirements and customer needs.

4.3.2.5 *Prioritizing technical requirements (Section 5)*

Determining the importance weight and the relative weight of the technical requirements is represented in Figure 4-13 by references 5A through 5E of the figure. These values are calculated as follows:

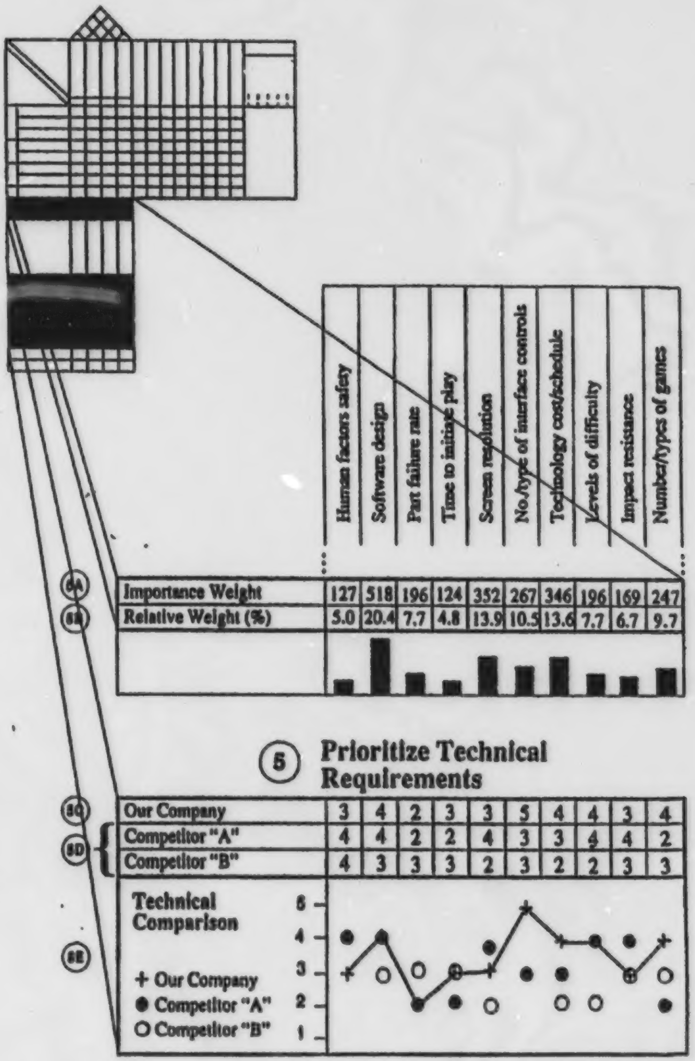
5A. Importance Weight — The importance weight of the technical solutions is calculated as the sum of the value of the relationship (9, 3, or 1) multiplied by the relative weight of the customer need. For example, in our video game analysis the importance weight of the fourth column "time to initiate play" is represented as the sum of the following customer needs times their relative weights (Column 21).

Easy to use	(9 × 10.3)	=	92.7
Everybody can use it	(3 × 6.0)	=	18
Wide assortment of action	(1 × 12.9)	=	12.9
Sum	124	=	123.6

Each of the columns is calculated in the same way so as to determine the relative weight of each of the technical solutions as compared to the customer needs.

5B. Relative Weight (Technical Requirements) — Once all of the columns have been totaled to determine the importance weights (5A) then the relative weights can be calculated through a normalization as was done in the calculation of the relative weights for the customer needs. In the video game example, the sum of the importance weights equals 2542. In order to determine the relative weight of each of the technical requirements columns, one merely has to divide the importance weight by the total weight, which will yield a percentage. Normalization of that number is then accomplished by multiplying each of the relative weight percentages by 100 as illustrated in Figure 4-13.

Once the relative weights of the technical requirements have been determined, it is important to examine the results to determine the key technical requirements that can help satisfy the customer needs. The relative weights



	Human factors safety	Software design	Part failure rate	Time to initiate play	Screen resolution	No./type of interface controls	Technology cost/schedule	Levels of difficulty	Impact resistance	Number/types of games
Importance Weight	127	518	196	124	352	267	346	196	169	247
Relative Weight (%)	5.0	20.4	7.7	4.8	13.9	10.5	13.6	7.7	6.7	9.7
Our Company	3	4	2	3	3	5	4	4	3	4
Competitor "A"	4	4	2	2	4	3	3	4	4	2
Competitor "B"	4	3	3	3	2	3	2	2	3	3

Figure 4-13 Video game Core QFD Matrix example — Section 5: Prioritize Technical Requirements.

are usually presented graphically through bar graphs to provide quick analysis of the key technical requirements. In the video game example there are three technical requirements which rank very high when compared with the customer requirement. Those three technical requirements are (1) software design, (2) screen resolution, and (3) technology cost/schedule. When examining customer needs for the video game, the design team knows that the top 30 to 40% of the technical requirements are going to probably drive the design and ultimate manufacture of the video game in terms of satisfying customer needs. By selecting the highest ranking technical requirements the design team would want to investigate them further and determine how the development of these elements are going to basically drive the design. The design team does not ignore the other elements of the design in favor of these elements, but rather investigates these candidates rigorously and examines the overall data to determine what can be done in these three areas to make sure the customer needs are satisfied. Additionally, if there are certain technical difficulties in any of these three areas, the design team knows that they will have difficulty in satisfying customer needs and that there may be a need for improvement in these areas through investment of either time or money.

5C, 5D, and 5E. Competitive Rating (Technical Performance) — Another element of Section 5 of the matrix is to determine how well both you and your competitors are meeting the technical requirements (based on a scale of 1 to 5, with 5 being the highest). As with the competition comparison represented in 2I of Figures 4-8 and 4-10, the technical comparison in Section 5E of Figure 4-13 will give a rough estimation of whether or not you currently possess some of the technical requirements in-house in order to meet the customer needs defined in the product or service. It is important to benchmark against your competitors in this area to determine if there is a technical gap, or a technical superiority, which again gives the team another element for focus to provide a superior product and meet those customer needs. In Figure 4-13 the numerical values of 1 through 5 have been transferred into symbols for visual comparison of the video game manufacturer and its two closest competitors. Although this is not necessary when taking a look at the initial Core QFD Matrix, teams often translate information into a visual, as well as numerical, representation for quick overall comparison. Also, many people interpret data better if they see it visually as opposed to examining information based solely on numbers.

Technical benchmarking is accomplished much in the same way as benchmarking satisfaction of customer needs. In order to determine how you compare to your competitors in certain technical areas, a company can use techniques such as laboratory testing, bench testing, and prototype simulation, and use both internal and external experts to support any rationale for determining capability. Companies, especially those in software or high-tech fields, often possess a great amount of data on their own technical capabilities, as well as the competitors' or the industry's capabilities. This information is often informally as well as formally exchanged, and also can be determined by comparing how well a company meets standardization criteria (UL, ISO 9000, etc.)

Comparing this technical requirement benchmarking with customer needs benchmarking also acts as a check between marketing and engineering. If the competitive benchmarking of a customer need shows that the competition is better at meeting that need than the company, and the competitive benchmarking of the technical requirements fulfilling that need are ranked higher than the competition, either marketing is not recognizing and selling a strength it has to offer to the customer, or engineering is overrating technical capability.

4.3.2.6 Set specific targets (Section 6)

6A. Target Values — After the technical solutions have been determined, and relative importance and weight have been assigned to them, the next step is to determine target values for those technical solutions. This step is often overlooked when conducting the Core QFD Matrix. Technical solutions, as mentioned above, are those elements that you plan on controlling in order to meet the customer needs. In order to control something you must also be able to measure that element; and if you are going to measure it there should be a target value that you want to achieve. Establishing the target values can focus a design team's efforts, as well as provide additional information about the design parameters.

When a team determines target values, they first should try to assign specific target values to as many of the requirements as possible. In assigning the target values it is important to define specific goals or ranges for designers, engineers, or individuals determining the service parameters. If a team spends sufficient time in setting target values, they can establish targets for trade studies and analysis. They can later use techniques such as Experimental Design to determine the validity of the target value as well as the methodology for reaching that target value. Figure 4-14 illustrates sample target values developed for the video game. Often these target values can be based upon information gathered in the original market surveys, or in the initial benchmarking of the technical requirements against competitors or the industry. For example, the time to initiate video game play is targeted at an average time of 1 min. This would be based upon such elements as the customer's impatience in wanting to start playing a new video game, as well as the current accepted market time frame for initiation of play on video games. Target values can also be based upon industry standards or requirements.

Target values can be a range, as well as a specific technical target that must be hit exactly. When considering the development of target values, the design team should also consider the results of designed experiments that define optimum values, historical or operator data, statistical process control data, and other benchmarking tools. It is important that each target is measurable and that the team can agree on the methodology for that measurement. These targets should be established at levels that are equal to or better than the competition, but should also take into consideration resource allocation and time commitment. There have been cases when a design team has examined target values that they feel are critical for certain technical

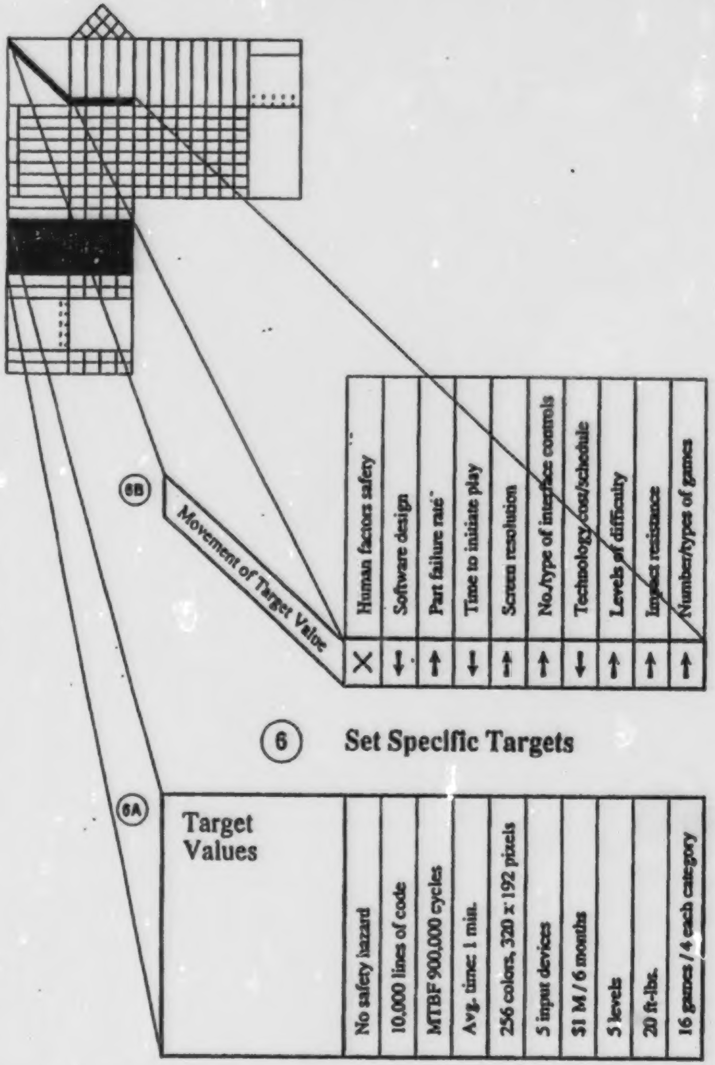

6B
Movement of Target Value
Human factors safety
Software design
Part failure rate
Time to initiate play
Screen resolution
No./type of interface controls
Technology cost/schedule
Levels of difficulty
Impact resistance
Number/types of games
X
↓
↑
↓
↑
↑
↓
↑
↑
↑
6
Set Specific Targets
6A
Target Values
No safety hazard
10,000 lines of code
MTBF 900,000 cycles
Avg. time: 1 min.
256 colors, 320 x 192 pixels
5 input devices
$1 M / 6 months
5 levels
20 ft-lbs.
16 games / 4 each category

Figure 4-14 Video game Core QFD Matrix example — Section 6: Set Specific Targets.

requirements. However, upon further examination and investigation, the team discovered that these technical target values could not be attained, which ultimately meant abandoning the project. Although this can be discouraging, it also prevents unnecessary and wasteful investment of precious resources on a project that would ultimately end in failure because of an inability to meet a technical requirement that drives a design or service.

Finally, the design, product, or service team should keep in mind that these technical values are often only the *initial* target values that should be reassessed after additional data has been gathered. Target values often can be revised based upon detailed analysis such that they still meet the perceived customer requirement allowing the project to continue.

6B. Movement of the Target Value — Along with determining the actual target values, the team should also consider the movement of those target values for improvement or optimization of the design. This is represented in Figure 4-8 as 6B and is shown for the video game in Figure 4-14, located at the top of the chart directly under each technical solution. There are three entries to be made in this particular column: (1) ↑ indicates an increase in the desired direction of the target value, (2) ↓ indicates a decrease in the desired direction of the target value, and (3) an "X" indicates that a specified nominal value must be attained. In the video game example the team would want to decrease the actual time to initiate play because that would allow the customer quicker access to actually playing the game. Therefore a ↓ is placed under "time to initiate play" (Column 4). It is important to remember that these arrows are based on the target values that have been set in Section 6A. As a second example, the first technical requirement, "human factors safety," would probably best be represented by the meeting of United Laboratories requirements. Therefore, an "X" is placed in Column 1 indicating that certain minimum standards must be met.

4.3.2.7 *Identify technical interactions (Section 7)*

Figure 4-15 illustrates how to use the "roof" of the Core QFD Matrix to examine the correlations among the technical requirements themselves. The roof of the Core QFD Matrix objectively measures the interaction between the technical requirements and provides early recognition of positively and negatively correlated technical solutions as determined by the design or service team. The roof of the Core QFD Matrix is one of the more advanced tools that can be used to substantiate intuitive suspicions that focus on increasing the performance of a certain technical area can have both positive and negative impacts on other technical requirements. From a mechanical viewpoint, the roof is completed using four symbols represented in Figure 4-15. Those four symbols represent a range of correlation from strongly negative to strongly positive correlations. In the video game example, technical elements such as part-failure rate and impact resistance are correlated using the strongly positive symbol. This means that if you improve the impact resistance of the product, you would most likely improve the ability of that element to resist failure. Likewise, making the video game more failure-resistant may also positively correlate to greater impact resistance. On the other end of the spectrum, trying to increase screen resolution (which would most likely increase cost and possibly impact schedule) has a negative correlation to technology costs and schedule. This means that when a design team is looking at reducing cost or shortening the schedule they have to take into consideration that this may affect their ability to increase screen resolution with new technology developments. Similarly, if the number and type

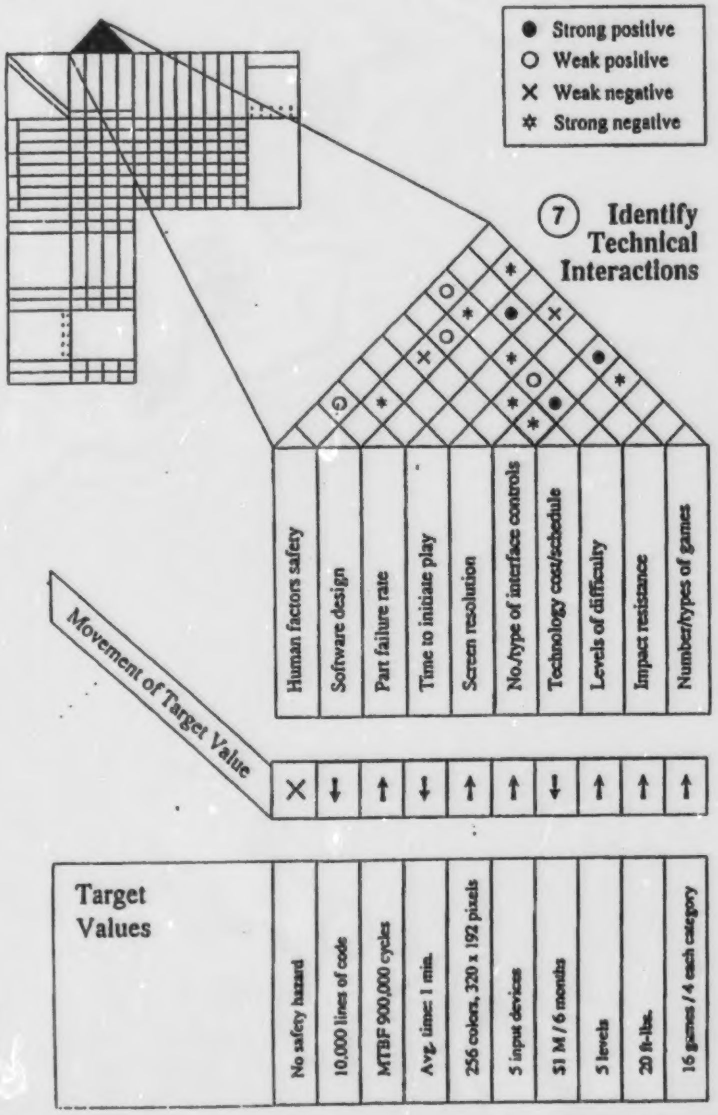

● Strong positive
○ Weak positive
✕ Weak negative
✲ Strong negative
7 Identify Technical Interactions
Human factors safety
Software design
Part failure rate
Time to initiate play
Screen resolution
No./type of interface controls
Technology cost/schedule
Levels of difficulty
Impact resistance
Number/types of games
Movement of Target Value
Target Values
No safety hazard
10,000 lines of code
MTBF 900,000 cycles
Avg. time: 1 min.
256 colors, 320 x 192 pixels
5 input devices
$1 M / 6 months
5 levels
20 ft-lbs.
16 games / 4 each category

Figure 4-15 Video game Core QFD Matrix example — Section 7: Identify Technical Interactions. This example further illustrates the interaction between "Number of types of Interface controls" and Technology costs/schedules.

of interface controls increase, it would have a significant negative impact on the ability to reduce the use of new technology as illustrated in Figure 4-15. By identifying these correlations early in the process, the team can competently discuss tradeoffs and potential "gotchas" in the technical design that may not otherwise be apparent until later in the design process and after the expenditure of potentially large sums of money.

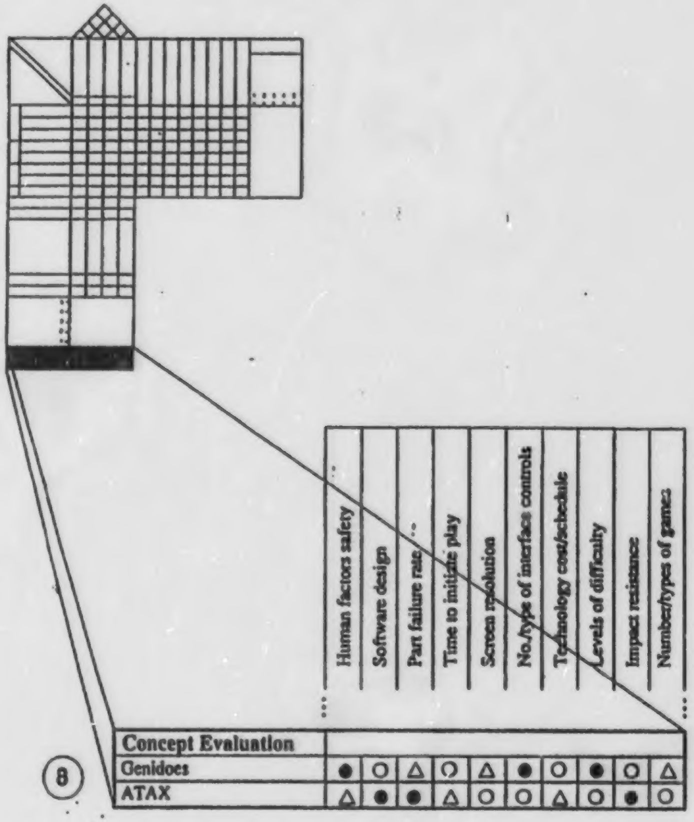
When conducting facilitation to complete the roof of the Core QFD Matrix, it is best to use the most knowledgeable members of the team for the particular technical solutions in order to best identify interrelationships between the technical solutions. This part of the matrix can be one of the most difficult to fill out because it requires the anticipation of problems and potential tradeoffs between departments and product characteristics; therefore, it is often helpful to fill out the entire matrix, with all team members, and then use a subset of the key team members to complete the roof. This gets the team moving in the various areas before having a follow-on session when additional information has been gathered on the actual technical requirements.

4.3.2.8 Concept evaluation (Section 8)

After the first seven sections of the Core QFD Matrix have been fully determined, the next step is to develop various design concepts that take into consideration many of the technical solutions that have been developed in response to the customer needs. This step is for more advanced applications of QFD and is usually conducted by a team that is familiar with the rest of the Core QFD Matrix, and continues with the Integrated QFD Approach™ previously discussed in Chapter 3 (Figure 3-8). In order to complete Section 8 of the Core QFD Matrix the team must develop system alternatives to be evaluated and compared for determination of how well technical requirements are met. Team members may compare their initial best concepts with the requirements to analyze preliminary ideas for major technical gaps and for competitive advantages. However, the authors recommend further development of these concepts by developing functional flow diagrams and brainstorming concept options to meet the technical needs. This will also refine optional system alternatives that can be re-evaluated in the concept evaluation step of the Core QFD Matrix.

A major criticism of other QFD methods has been that these other systems only map what team members already know. The addition of functional analysis and concept brainstorming, further explained in Chapter 7, provides the means to stimulate team creativity in developing products, services, and business practices. These steps should be performed prior to considering Section 8 complete. Utilizing Section 8 of the Core QFD Matrix is a key element in full systems integration of the QFD analysis.

As mentioned earlier, a product or service concept can be evaluated against all other technical requirements as related to the customer needs. When developing a new product or service, there are often multiple ways or concepts that can be developed to meet both the overall customer needs and



Concept Evaluation	Human factors safety	Software design	Part failure rate	Time to initiate play	Screen resolution	No./type of interface controls	Technology cost/schedule	Levels of difficulty	Impact resistance	Number/types of games
Genidoes	●	○	△	○	△	●	○	●	○	△
ATAX	△	●	●	△	○	○	△	○	●	○

Figure 4-16 Video game Core QFD Matrix example — Section 8: Concept Evaluation.

developed in response to potentially conflicting requirements as identified in Section 7 (the roof) and the technical requirements themselves.

For the purposes of this example, we will assume that CVM has conducted further analysis and developed two system alternatives: ATAX and Genidoes, two potential game systems (see Figure 4-16). The ATAX concept design for the video game maximizes the ability to meet Software Design, Part-Failure Rate (low), and Impact Resistance. However, doing so means that the cost has gone up and the system only ranks a "1" (a triangle) in this category. This may mean that ATAX increases the cost to such an extent that it may not be commercially feasible. On the other hand, the Genidoes concept selection may go for a more middle-of-the-road technical solution when considering Software Design (a "3"), but significantly decreases the cost of the product making it more appealing to a larger audience. Neither system meets the requirement of Video Screen Resolution with a "9," which may mean that neither concept maximizes satisfying one of the key technical requirements. This may be because of the cost factor, but it is a serious consideration and more systems may need to be evaluated in order to determine if there is one that delivers screen resolution without being cost-prohibitive.

Section 8 allows the design or service team to measure each of the various concepts selections, in total, against the customer needs. When doing this the team can determine if a single concept may be high in all areas except one or whether another concept meets more of the customer needs than other selected concepts. Often, there is also the possibility of selecting elements from each of the concepts to obtain the most effective systems design that satisfies the highest-ranked customer needs and leaves no gaps in meeting the technical requirements.

4.3.2.9 *The complete Core QFD Matrix*

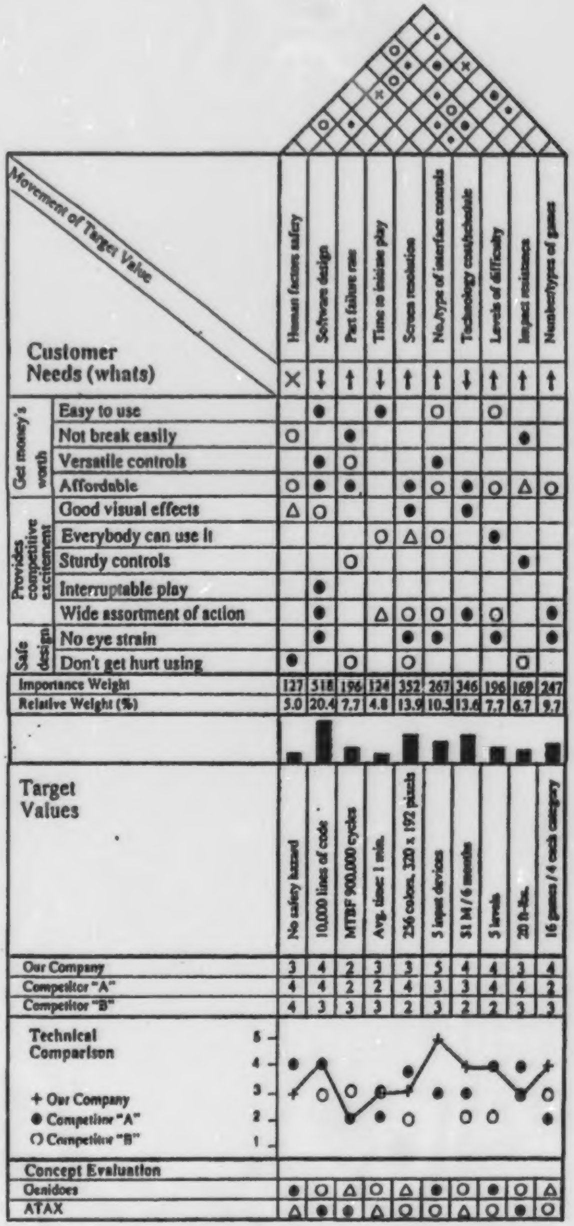
Figure 4-17 assembles all of the information developed for the CVM example in the eight sections of the Core QFD Matrix. This figure demonstrates just how compact the matrix is and how much information it can hold. However, just compiling this information does not mean the team is through evaluating the matrix. The next step is to evaluate the information for completeness and accuracy. This step is discussed in Chapter 5.

4.4 *Automating the completion of the Core QFD Matrix*

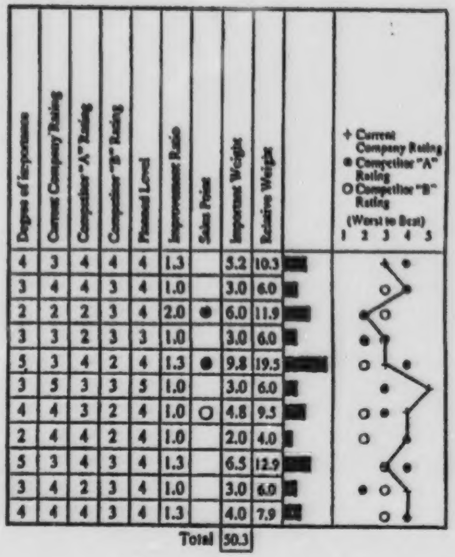
The Core QFD Matrix can often most effectively be completed by using a computerized tool that does all of the calculations given above, and also allows for modification of the various elements of the Core QFD Matrix. This allows teams to tailor the matrix to specific processes, or to use different values or rankings. There are several software programs to address this need, but the authors have found that one program, QFD/Capture (manufactured and sold by International TechneGroup Incorporated), has excellent flexibility and adapts well to the Core QFD Matrix application.

4.5 *Chapter summary*

1. The Core QFD Matrix is the heart of the Integrated QFD Approach™. It is a product, service, and process planning matrix used to depict customer needs and design, service, and business operations requirements, to target goals, as well as for evaluation of competitive product, service, or business operations.
2. The important point in gathering data for the QFD activity is to understand the needs of the customer fully, and that is often best done by asking the customer directly. This is why more and more companies are bringing the customer into the design and development process — making the customer a part of the QFD activity.



Customer Needs (whats)		Human factors safety	Software design	Part failure rate	Time to initiate play	Screen resolution	No./type of interface controls	Technology cost/schedule	Levels of difficulty	Impact resistance	Number/types of games
Movement of Target Value		X	↓	↑	↓	↑	↑	↓	↑	↑	↑
Get money's worth	Easy to use		●		●		○		○		
	Not break easily	○		●						●	
	Versatile controls		●	○			●				
	Affordable	○	●	●		●	○	●	○	△	○
Provides competitive excitement	Good visual effects	△	○			●		●			
	Everybody can use it				○	△	○		●		
	Sturdy controls			○						●	
	Interruptable play		●								
	Wide assortment of action		●		△	○	○	●	○		●
Safe design	No eye strain		●			●	●		●		●
	Don't get hurt using	●		○		○				○	
Importance Weight		127	518	196	124	352	267	346	196	169	247
Relative Weight (%)		5.0	20.4	7.7	4.8	13.9	10.5	13.6	7.7	6.7	9.7
Target Values		No safety hazard	10,000 lines of code	MTBF 900,000 cycles	Avg. time: 1 min.	256 colors, 320 x 192 pixels	5 input devices	$1 M / 6 months	5 levels	20 ft-lbs.	16 games / 4 each category
Our Company		3	4	2	3	3	5	4	4	3	4
Competitor "A"		4	4	2	2	4	3	3	4	4	2
Competitor "B"		4	3	3	3	2	3	2	2	3	3
Concept Evaluation											
Oenidoes		●	○	△	○	△	●	○	●	○	△
ATAX		△	●	●	△	○	○	△	○	●	○


+ Current Company Rating
● Competitor "A" Rating
○ Competitor "B" Rating
(Worst to Best)
1 2 3 4 5

Degree of Importance	Current Company Rating	Competitor "A" Rating	Competitor "B" Rating	Planned Level	Improvement Ratio	Sales Point	Important Weight	Relative Weight
4	3	4	4	4	1.3		5.2	10.3
3	4	4	3	4	1.0		3.0	6.0
2	2	2	3	4	2.0	●	6.0	11.9
3	3	2	3	3	1.0		3.0	6.0
5	3	4	2	4	1.3	●	9.8	19.5
3	5	3	3	5	1.0		3.0	6.0
4	4	3	2	4	1.0	○	4.8	9.5
2	4	4	2	4	1.0		2.0	4.0
5	3	4	3	4	1.3		6.5	12.9
3	4	2	3	4	1.0		3.0	6.0
4	4	4	3	4	1.3		4.0	7.9
						Total	50.3	

Figure 4-17 (continued)

3. Supporting techniques and tools in developing a Core QFD Matrix include brainstorming, affinity diagraming, and tree diagraming. These methods stimulate the team's creativity, develop and organize information quickly through a structured process, and provide visualization of relationships at various detail levels, which can reveal any gaps or holes in the sequence of information.
4. A detailed reference guide to completing a Core QFD Matrix is provided in Appendix A.
5. The Core QFD Matrix has common elements with all the QFD matrices used in the Integrated QFD Approach™. These steps are highlighted in the following eight steps:

Step 1. Identify Customer Needs — Defines customer needs in a hierarchical fashion.

Step 2. Prioritize Needs and Conduct Competitive Benchmarking — Provides a relative prioritization of customers' needs based on the importance to the customer, competitive assessments, in-house

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- **Step 3. Develop Technical Requirements** — Defines the product, service, and business operations in a hierarchical fashion that can be controlled to satisfy the customers' needs.
- **Step 4. Correlate Technical Requirements to Customer Needs** — Provides an indicator of how each technical requirement impacts the ability to meet the customers' needs.
- **Step 5. Prioritize Technical Requirements** — Provides a numerical and graphical representation of prioritized technical requirements to be used as a basis for developing an integrated plan of action to improve products, services, and business operations.
- **Step 6. Set Specific Targets** — Defines measures for a successful product, service, or business operation that can be integrated into product specifications, service, and business procedure guides.
- **Step 7. Identify Technical Interactions** — Defines conflicting and redundant performance system goals. These interactions are further analyzed in system trade-off studies and process improvement analyses.
- **Step 8. Perform Concept Evaluation** — Products, services, and business operation concepts can be evaluated against technical requirements and related to customer needs. Each independent element of a particular concept can be evaluated for strengths and weaknesses as compared to the performance targets set during the QFD analysis.

6. Once the Core QFD Matrix is complete, it should be analyzed for completeness, adequacy and consistency, which is discussed in Chapter 6.

chapter five

Analyzing the Core QFD Matrix

The difficulty is not in catching the Tiger;
It is what to do with it when you've got it by the tail!

5.0 Ensuring an accurate matrix

After a team has developed the Core QFD Matrix, the work is hardly over. The next step in using the matrix as shown in Figure 4-8 is to evaluate the information on which the team based the prioritized technical requirements and customer needs, and create an integrated plan — right?

Wrong.

If you have carefully followed the steps to construct the matrix, and assembled all of the information to be considered, the next step is to conduct a cross-check of the matrix itself to see if the information you have put into it and the priorities it yielded make sense. The matrix should not be used as a substitute for critical thinking, but as a lens to focus a team. Judgment should never be surrendered for the sake of a method or tool. If precautions are not taken to ensure that biases or lack of knowledge (both technical and about the customer) have not corrupted the analysis, the results will be limited. It is axiomatic to say that no approach is 100% foolproof, but no method of analysis is useful unless fundamental checks can be employed to determine whether or not the majority of the analysis can be relied upon for accuracy. The QFD matrix must also be capable of analysis for completeness, bias, and adequacy. Therefore, it is necessary to take a look at the format of the matrix before interpreting the data to create an integrated plan (the interpretation of the matrix and how it fits into an integrated plan is discussed in Chapter 6).

5.1 Evaluating the Matrix for completeness

The reader has seen how the Core QFD Matrix is an extremely effective tool for prioritization of customer needs, prioritization of technical requirements, and identifying the various relationships between the two. It is also an extremely effective tool for organizing a team, developing a strategy for a new product or service, or re-evaluating processes for process improvement. But how do you know if the matrix is complete? Does it include all of

ANNEX O TO
23 QWG AOR MFR

TERMS OF REFERENCE FOR SPECIAL WORKING PARTY
ON
SOLDIER SYSTEM ANALYSIS

1. Authority. The Special Working Party on Soldier System Analysis, short title SWP SSA, is established by the Washington Standardization Officers (WSO) under the provisions of the Basic Standardization Agreement, 1964.

2. Command and Reporting Channels. SWP SSA is under the direction of, and reports to, the Standing Chairman QWG AOR.

3. Responsibilities. The SWP responsibilities are to:

a. Produce and maintain formal agreements among the ABCA Armies to achieve the standardization tasks assigned in the QWG AOR Program Plan of Action (POA).

b. Exchange information among the ABCA Armies on materiel and non-materiel issues, which support the QWG AOR POA, in the area of OR.

4. Tasks. The authorized tasks of SWP SSA are to:

a. Produce a QAP describing a common set of Measures of Effectiveness (MOE) and Measures of Performance (MOP) through the exchange of information on each ABCA Armies' Soldier System functionalities and capabilities.

b. Produce a QAP to assist in coordination of data collection with other fora (e.g. QWG Inf and TTCP) including Soldier System human performance, engineering design, and field trials data to facilitate system assessment within the common set of MOEs and MOPs.

c. Produce a QSTAG to achieve a common set of Operational Analysis (OA) methods to quantify changes to unit performance and combat effectiveness attributable to alternative soldier system concepts.

5. Membership. The SWP will comprise:

a. A standing chairman detailed as Mr J. Coleby, AS DSTO, Salisbury, South Australia.

b. Delegation members (Subject Matter Experts) from each Army at the discretion of the respective Armies.

6. Method of Working. The SWP is to operate in accordance with QSOPs. It is to meet at the recommendation of the Standing Chairman QWG AOR and approval of WSO and Armies.

7. Liaison. The SWP is to maintain liaison with the following related international fora:

a. QWG Inf

b. TTCP TLG-8

c. NATO WG - Soldier Modernisation Program.

8. Time Frame of Work. The continuation of the SWP is to be reviewed at each QWG AOR meeting. The SWP will be disbanded on completion of its work.

9. Review. These TOR are to be reviewed at each QWG AOR meeting, with a recommendation to WSO for the disbandment or continuation of this SWP.

10. Amendment. The TOR may only be amended on the authority of WSO. The QWG should submit any proposals for change to WSO through the PSO.

TASK ANALYSIS FOR SWP SSA

TASK:

Provide an Operations Research infrastructure and analysis capability to assist in the assessment of ABCA Armies' alternative soldier system concepts and integration plans.

STEP 1 Task Conditions

To assess the ABCA Armies' force capabilities, there is a need for an operations research capability to quantify the changes to unit performance resulting from changes in the equipment mix. The ABCA Armies are presently considering investing in their infantry soldiers and the Armies need to be able to answer questions about why and how much they need to invest.

Issues that have been noted in this area are:

a. The need to quantify changes to individual soldier and unit performance and combat effectiveness attributable to alternative soldier system concepts.

b. The optimal integration of the individual soldier with this equipment, including human factors such as heat stress, information overload and situational awareness.

c. The integration of the individual soldier with his unit, including human factors such as morale, teamwork , and communication.

The application of Operations Research techniques to Soldier System research and development efforts is severely limited by:

a. A lack of a common set of measures of effectiveness and performance.

b. Inadequate human psychological, physiological, and performance data.

c. Incomplete combat missions, vignettes and scenarios.

d. Insufficiently detailed digitized terrain.

e. An incomplete set of Soldier System analytical tools.

STEP 2 Outline of the Enabling Objectives

In order to do the analysis required to consider questions such as combat worth, the following are required:

a. Produce a common set of Measures of Effectiveness (MOE) and Measures of Performance (MOP) through the exchange of information on national Soldier System functionality's and capabilities.

b. Coordinate data collection with other fora (e.g. QWG Inf and TTCP) including data on Soldier System human performance, engineering design, and field trials.

c. Produce a common set of Operational Analysis (OA) methods to quantify changes to unit performance and combat effectiveness attributable to alternative soldier system concepts.

Consensus on available models that was reached by ABCA participants at a Soldier Modeling Workshop held in Ottawa, 27-31 January 1997, indicated:

a. The US model IUSS was the most appropriate and available model for detailed low level Soldier System analyses.

b. The UK model CAEN was the next model in the overall Soldier System simulation hierarchy.

c. The US models JANUS and CASTFOREM would, most likely, follow CAEN in this hierarchy.

Some issues related to providing an increased capability for soldier modeling involve scientific and technical development of analytical tools including models and simulations as well as specific data gathering in the areas of human factors and human performance. These issues might be better addressed through the TTCP. Such issues include:

a. Making CAEN platform independent.

b. Ensuring that the output of IUSS is in an appropriate form to be easily input into CAEN.

c. Making CAEN object oriented.

d. Developing new algorithms or methods of analysis.

e. Developing methodologies for and collecting human performance data.

STEP 3 Necessity for Standardization

All the ABCA Armies are considering modernizing their infantry in a similar timeframe. In order to facilitate the exchange of data and information, and to make cooperation possible, it is necessary to talk the same language, which in this case also means the same scenarios, terrain and analytical tools.

STEP 4 Deliverables

a. Produce a QAP describing a common set of Measures of Effectiveness (MOE) and Measures of Performance (MOP) through the exchange of information on each ABCA Armies' Soldier System functionality's and capabilities.

Method of Delivery - QAP Completion Date --Aug 98

b. Produce a QAP to assist in the coordination of data collection with other fora (e.g. QWG Inf and TTCP) including Soldier System human performance, engineering design, and field trials data to facilitate system assessment within the common set of MOEs and MOPs.

Method of Delivery - QAP Completion Date - Aug 98

c. Produce a QSTAG to achieve a common set of Operational Analysis (OA) methods to quantify changes to unit performance and combat effectiveness attributable to alternative soldier system concepts.

Method of Delivery - QSTAG Completion Date - Aug 98

ANNEX I
DOR(J&L) RN9812
July 1998

NATO SOLDIER MODERNISATION

MEASUREMENTS FOR ANALYSIS

3 April 1998

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Appendix 1 - Example vignette descriptions

1. Introduction

1.1 Objective

1.1.1 The objective of this document is to outline an approach to quantifying the achievement levels of individual soldiers and groups of soldiers. This approach is intended to provide guidance to the soldier modernisation modelling community and provide a framework within which data can be collected and exchanged.

1.1.2 Soldiers rarely undertake military activities on their own. However, as it is the individual soldier who is given capability (training, equipment etc), a mechanism must be found to relate this to the level of achievement of the team.

1.1.3 In meeting this objective, it has been necessary to identify and describe the activities undertaken by dismounted infantry.

1.2 Measurement scheme

1.2.1 Operational analysis should identify the need(s), if any exist, for soldier modernisation. The soldier modernisation community must then be responsible for meeting the need(s) identified by the OA. The assessment framework will enable tools to be focused in this respect. The basis of the framework is a proposal for the measurement of levels of assessment.

1.2.2 **Key definitions:** Soldiers perform as individuals or in groups to achieve particular tasks. A series of tasks comprise a vignette. A vignette can be considered as the smallest resolvable military operation e.g. a section (squad) attack.

1.2.3 Each task or collective task at any force level will have a mission associated with it e.g. dig a trench, defend the trench against a RED section attack, conduct defensive operations within the context of the company frontage.

1.2.4 To be of maximum use to the soldier modernisation community and especially to the military, the modelling tools should be able to predict the effectiveness levels to be achieved by individual soldiers with various levels of capability when undertaking specific missions. It should then be possible to determine the key measures of effectiveness (MoE) at the soldier level that influence the manner in which the mission was achieved .

1.2.5 The individual soldier's effectiveness in achieving a particular task is based on his capabilities. For each task, there is likely to be a blend of capabilities required, drawn from the five NATO capability areas.

1.2.6 The individual soldier's capability to undertake a particular task is derived from his own basic ability combined, in most cases, with soldier equipment. The measurement framework must thus embrace the factors that combine to produce levels of capability (from the soldier system).

1.2.7 Given the need to specify equipment performance as a factor that contributes to soldier capability, the measurement scheme should also take account of the composition of the equipment. Specifically, equipment can be considered of consisting of sub system, module, basic element and hardware component levels. These levels are further amplified at reference 1 and this links the measurement scheme with the modular structure approach defined at reference 1.

1.2.8 As soldier modernisation embraces the command and control environment in which groups of soldiers achieve the tasks set, an analytical approach is also required to assess C2 capability metrics. Thus the concept of measuring C2 capability has been introduced but the exact performance metrics have yet to be established.

1.3 Previous related work undertaken by NATO LG3 WGIII

1.3.1 The measurement scheme proposed herein links to the NATO capability areas (reference 2) and embraces the modular approach (reference 1).

1.4 Link with trials

1.4.1 In order to provide data for model validation and to capture current performance deficiencies, the measurements for analysis scheme can be linked with practical field trials. Within the measurement framework, trials are a mechanism for:

a. determining how well soldiers currently achieve their tasks;
b. establishing evidence for current capability shortfalls;
c. providing a basis for evaluating improvements against a current performance baseline;
d. providing data for model validation.

1.5 NATO ST

1.5.1 The common measurement framework could be developed to allow a mechanism where national capability deficiencies could be compared. It would then be possible to consider moving to a NATO ST for soldier modernisation based on common need. This would complement the approach already underway, based on modules, that is detailed at reference 1.

2. Measurement levels

2.1.1 **Introduction:** In order to achieve the needs of the soldier modernisation trials and modelling communities, the following measurement levels have been identified.

2.1.2 **Mission:** Given the need to be consistent with the military interpretation of the term 'mission', which can be set for any size of force, the measurement levels should be independent of force size to provide maximum flexibility.

2.2 Level 0: the force capability level

2.2.1 The measure of force capability reflects a campaign level measure which can be used by higher level decision makers to conduct capability trade-offs. It is commonly obtained by the aggregation of MoEs associated with the mission in the context of mission occurrence analysis.

2.2.2 This level is identified as **level 0** but not detailed further at this time.

2.3 Level 1: the mission level

2.3.1 A mission can be set for any level of force. For the purposes of the soldier modernisation community, the force level will normally be the team, section (squad), platoon or company.

2.3.2 Modelling should be able to predict the outcome at the mission level. The performance metric at the mission level is an indication of how well the mission has been achieved. For example, for a mission objective 'to take a hill and hold for 2 hours' could, for example, encompass the following metrics (one of which may be subjective):

a. whether the hill was taken and held for the duration (was the goal achieved Y/N?);
b. the time taken to take the hill;
c. own losses;
d. own losses (dead);
e. own losses (wounded);
f. ammunition expended;
g. the ability of the unit to continue successful operations.

2.3.3 From the military perspective, these measurements are perhaps equivalent to that information which a mission commander would report back to the higher command level having achieved the mission objective.

2.3.4 Point a. is either success or failure. Points b. to g. can be considered as the collective MoEs that describe the quality of mission success or failure.

2.3.5 The mission level measurements are thus split into two components as follows:

a. level 1a is whether the outcome was achieved or not (MoO);
b. level 1b provides the collective MoEs that qualify the outcome.

2.4 Level 2: the individual soldier level

2.4.1 The level 1 missions are comprised of a series of one or more linked tasks undertaken by individual soldiers under the direction of their commander. A task within a mission undertaken by a soldier is defined as a level 2 task. Individual soldiers will achieve a level of effectiveness for particular tasks that comprise a mission.

2.4.2 Examples of tasks within a mission are as follows:

a. move to assembly area;
b. establish movement formations;
c. conduct reconnaissance;
d. engage enemy.

2.4.3 The measurement of how well these tasks were achieved could be expressed in the following terms:

a. level of control over section (squad) manoeuvre;
b. number of detections;
c. time required to switch from one target to another;
d. number of hits;
e. level of control over direction and rate of fire.

2.4.4 The term for the effectiveness achieved by soldiers in undertaking tasks that comprise the mission is therefore **'(soldier) effectiveness level'** and is defined as level 2a.

2.4.5 The MoEs for all soldiers for all tasks will impact on the overall measurements of outcome at the mission level.

2.4.6 **Capabilities to undertake level 2 tasks:** For each tasks at level 2 there is an amount of soldier system capability available. Available capability can be either that capability before 'modernisation' or improved capability after improvements are made. Examples of capability areas are:

a. communication;
b. position locating;
c. lethality.

2.4.7 The soldier capabilities to undertake particular task are expressions of measures of performance (MoPs). Lethality examples are:

a. detection range;
b. accuracy;
c. number of rounds carried;
d. magazine change over time.

2.4.8 The term for expressing the measurement level associated with the application of capability to particular tasks is therefore the **'(soldier) performance level'** and is defined as level 2b.

2.4.9 The soldier's capability to undertake a particular task is derived from a combination of some or all of the following components (components of soldier capability):

a. his basic physical and mental performance (the 'man specification');
b. the level of skill acquired by the soldier applicable to the particular task, in which he is required to be effective, due to his training and experience (noting that this is subject to skills fade);
c. the modification of his ability due to his physical state;
d. the intrinsic performance of any equipment used by the soldier to enhance his capability for a particular task occurring during a mission.

2.4.10 Any deficiency in the man and/or his training may, but not necessarily so, be compensated for by the addition of suitable equipment or improved equipment. If the probable cause of the deficiency was established, the options for gaining an improvement could be identified (e.g. additional equipment or improved training).

2.5 Levels 3: the equipment level

2.5.1 The component associated with the equipment used to enhance soldier capability to undertake a particular task can be broken down into lower levels and are in the domain of the equipment manufacturers. These levels, using the definitions given in reference 1, are as follows.

a. **level 3a** - equipment sub system (the group of modules that contribute to the task);
b. **level 3b**- modules (a group of sub-modules that are physically linked);
c. **level 3c** -sub-modules (a group of basic elements that can be replaced or operated separately);
d. **level 3d** - basic element (a unique item or equipment that can be replaced when required);
e. **level 3e** - hardware component (an item that serves to form, compose or make up a unit or whole).

2.6 Summary of principal measurements for analysis levels

2.6.1 Table 1 summarises the measurement levels. Figure 1 provides a diagrammatic representation. It should be noted that the soldier state is identified as an aspect that will modify the soldier performance.

Level	Aspect	Addressing
0	(Force) capability	Campaign level performance.
1a	(Mission) outcome	Whether the mission was a success?
1b	(Mission) Collective effectiveness	How effective was the force in completing its mission?
2a	(Individual soldier) effectiveness	How effective were the individual tasks that comprise the mission achieved?
2b	(Individual soldier) performance	What were the capabilities available that contributed to the soldier's effectiveness achieved for a particular task?
3a	Equipment	Performance at sub system level.
3b	Equipment	Performance at module level.
3c	Equipment	Performance at sub-module level.
3d	Equipment	Performance at basic element level.
3e	Equipment	Performance at hardware component level.

Table 1: Summary of measurements for analysis levels

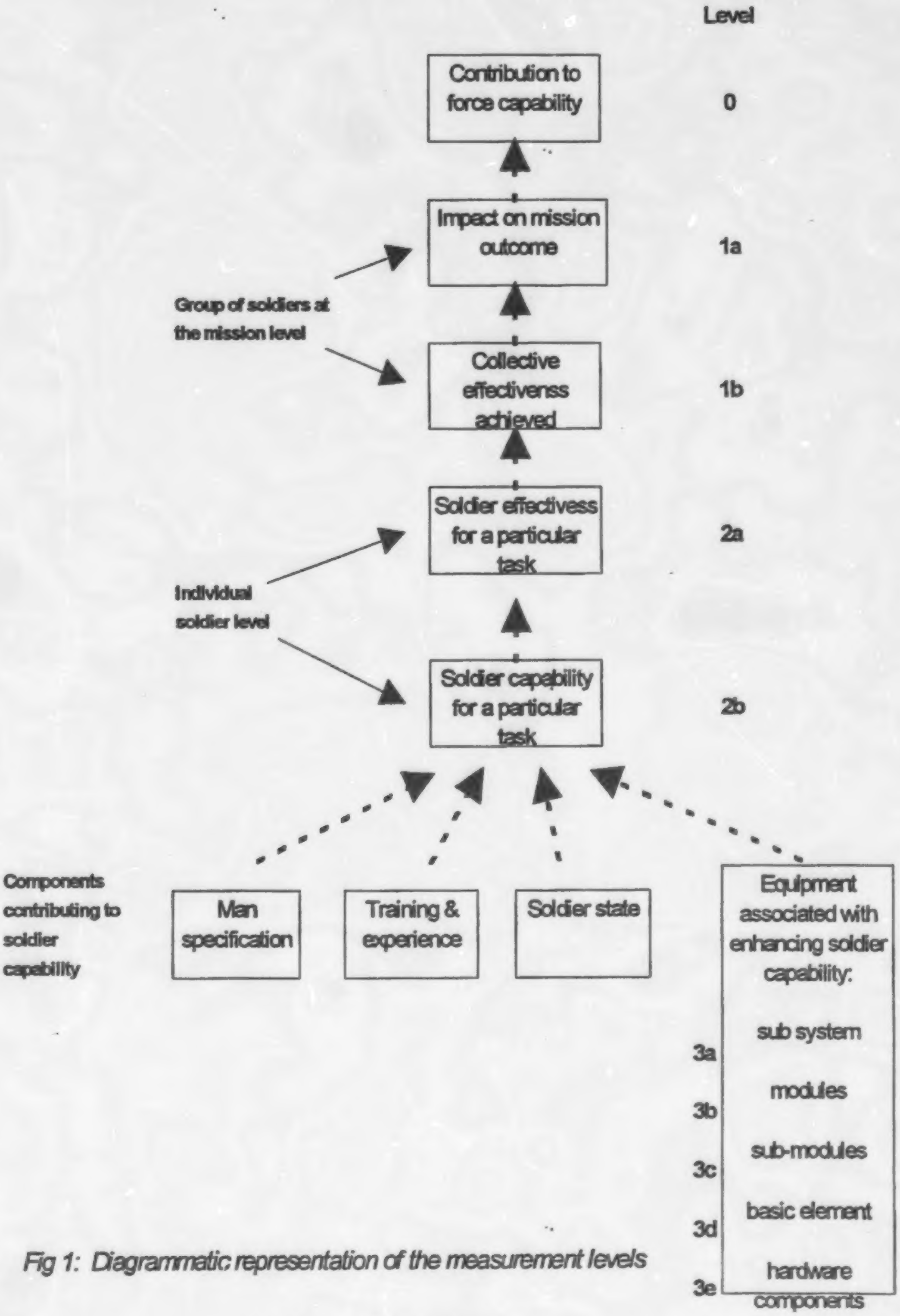
Level
Contribution to force capability
0
Impact on mission outcome
1a
Group of soldiers at the mission level
Collective effectivenss achieved
1b
Soldier effectivess for a particular task
2a
Individual soldier level
Soldier capability for a particular task
2b
Components contributing to soldier capability
Man specification
Training & experience
Soldier state
Equipment associated with enhancing soldier capability:
sub system
3a
modules
3b
sub-modules
3c
basic element
3d
hardware components
3e

Fig 1: Diagrammatic representation of the measurement levels

3. Mission and vignettes

3.1 Introduction

3.1.1 This part of the paper defines the tasks undertaken by soldiers or groups of soldiers in the dismounted role in the scenarios of interest.

3.2 Scenarios

3.2.1 A review of dismounted infantry missions has been undertaken in the context of the following scenarios:

a. offence;
b. defence;
c. delay;
d. transitional operations;
e. OOTW.

3.2.2 The first 4 are from ATP 35A agreed operations (NATO doctrine defining phases of war). OOTW will be addressed in section 4.

3.2.3 Dismounted infantry missions will occur in the following environments:

a. temperate;
b. mountain;
c. jungle;
d. desert;
e. urban;
f. maritime;
g. NBC.

3.2.4 NBC stands on its own as an environment even though it overarches all missions.

3.2.5 Although missions will not be identical in all scenarios, it can be postulated that the level 1 measurements may well be similar although the relative importance of individual level 1 measurements may vary. For example, political considerations may dictate that own force casualties during a recce patrol in are unacceptable in OOTW whereas casualties would be tolerated in a general war situation.

3.3 Vignettes

3.3.1 A mission has been defined as activities undertaken by groups of soldiers at company level and below. Analysis has shown that small groups of soldiers can be considered to undertake 17 generic group tasks that occur in nearly all scenarios/environments. Each of these generic activities has been termed a vignette and these primarily relate to the infantry section (squad).

3.3.2 Thus it is possible to compose missions for groups of soldiers by selecting a vignette or by linking with other vignettes. Vignettes associated with more than one group of soldiers can therefore be linked together to form larger group missions.

3.3.3 The vignette is thus a practical building block for constructing missions at company level and below. It is also convenient for the purpose of data gathering in trials when it can be difficult to obtain large numbers of trial troops and instrumentation. The main limitation of the vignette is that, on its own, it is not possible to explore fully C2 issues.

3.3.4 The generic vignettes are identified in the list below. Appendix 1 provides example descriptions. National preferences may result in alternative vignettes descriptions:

a. advance;
b. ambush;
c. armd vehicle destroy;
d. attack;
e. building/ bunker assault;
f. control of movement;
g. crowd control;
h. defence;
i. fighting patrol;
j. fire support;
k. observation post;
l. post combat;
m. pre combat;
n. recce patrol;
o. search;
p. security;
q. withdrawal.

3.3.5 Pre combat is the preparatory phase for the other vignettes and post combat is often the concluding phase of other vignettes.

3.3.6 A further point to be noted is that vignettes will occur at all levels of optical visibility, whether by day or night.

3.3.7 **Littoral:** The littoral environment is up to the edge of the beach.

3.4 Applicability of vignettes to environment

3.4.1 National preference would be expressed by selecting the appropriate vignettes of interest from the matrix of mission vs 'environment' as indicated in Table 2. Not all vignettes will be applicable e.g. crowd control in the jungle.

Ser	Environment	Temperate	Mountain	Jungle	Desert	Urban	Littoral	NBC
	Vignette							
1	Advance							
2	Ambush							
3	Armd Vehicle Destroy							
4	Attack							
5	Building/ Bunker Assault							
6	Control of Movement							
7	Crowd Control							
8	Defence							
9	Fighting Patrol							
10	Fire Support							
11	Observation Post							
12	Post Combat							
13	Pre Combat							
14	Recce Patrol							
15	Search							
16	Security							
17	Withdrawal							

Table 2: Summary of possible vignettes vs environment

4. OOTW considerations

4.1 Introduction

4.1.1 The existing importance of OOTW to some nations and the emerging importance of OOTW to others indicates that this section of the paper will need considerable development.

4.1.2 A review of the above vignettes has been undertaken in the context of their relevance to OOTW. Initial consideration suggests that all are considered relevant with the exception of defence.

4.2 Defence

4.2.1 Defence should perhaps not be included as OOTW operations are normally conducted from firm, fortified bases. It is true to say that they are defended locations but they are not the same as a defensive position. Vignette 16 - Security covers the practice of acting as part of the base security system. All other vignettes have application to a greater or lesser degree in OOTW.

4.2.2 However, while the essence of the vignette is the same in general operations as it is for OOTW, there are distinct differences. In OOTW the soldier is constrained by a more overt approach to operations which tends to place him at a tactical disadvantage and by very specific Rules of Engagement. These will necessarily have an impact at the soldier level.

4.3 Unique OOTW vignettes

4.3.1 It may therefore be necessary to establish a unique OOTW vignette list. At the very least it is recommended that there should be an OOTW specific Recce Patrol. This is to take account of the 'Hearts and Minds' and 'Re-assurance' aspects of this type of overt patrol. Its purpose and execution is somewhat different to the recce patrol in combat. The other 'fighting' vignettes (Serials 2, 3, 4, 5, 9, and 10) are also the same in execution as their war fighting counterparts although their initiation either tends to be reactive or is subject to closer control than their conventional counterparts.

4.3.2 Specific OOTW aspects that will need to be embraced particularly in the Recce Patrol include the following:

a. Were wanted personnel identified whilst on patrol?
b. Was it possible to track wanted vehicles?

4.3.3 'Deliver humanitarian aid' is not a dismounted section (squad) activity. 'Obtain information' is merely a detail within the overall framework of the patrol. The ability to gain information from the locals is not so much down to the capability of the soldier and his equipment, rather it is down to the willingness of the person being questioned to provide the answers. Therefore it is not something which is sensitive to technical improvement. There is perhaps a need to 'dress down' but still retain sufficient capability and this is particularly relevant where helmets are used as a platform.

4.3.4 In summary, there are no other specific OOTW activities other than the OOTW Recce Patrol proposed. Subjective collective MoE for imparting re-assurance need to be identified.

5. Measurements at the mission level

5.1 Objective

5.1.1 This part of the paper establishes the level 1b measurements, the collective measures of effectiveness MoEs, associated with the vignettes identified in section 3.

5.2 Selection of mission level collective MoEs

5.2.1 As the mission can be built from one or more vignettes, the collective MoEs pertaining to the mission can be 'built' from the collective MoEs for each of the component vignettes. Some component vignette collective MoEs of a mission may have less importance in the mission context and therefore could be discarded. National preference is acknowledged.

5.3 Goals

5.3.1 These are set in orders and are concise and are the basis for determining success/ failure criterion associated with level 1a. At the end of the mission it should be possible to have a clear success/ failure rating.

5.4 Collective MoEs

5.4.1 Analysis of the vignette exposes a pattern of key measurements which determine how well the vignette was achieved. There have also emerged some other critical measurements that would be necessary to provide the discrimination between different systems or different equipment mixes.

5.4.2 Table 3a below shows the suggested collective MoEs identified in the course of the analysis of the vignettes. Those numbered 1 - 9 inclusive (and 22 - 24) occur most frequently. The remainder are unique to one or (at the most) two missions.

5.4.3 Table 3b indicates how collective MoEs may be gathered.

Ser	Collective MoE	Interpretation
1	Enemy casualties	Enemy killed, incapacitated or captured such that they offer no further threat to own forces, expressed as absolute numbers for both. In trials, due to the limitations with instrumentation, it may only be realistic to measure numbers 'killed' and possibly captured. Casualties/enemy prisoners would feed into higher level modelling.

Ser	Collective MoE	Interpretation
2	Own casualties	Own forces killed, incapacitated or captured such that they are unavailable for re-tasking at the end of the mission, expressed as absolute numbers for both. In trials, due to the limitations with instrumentation, it may only be realistic to measure numbers 'killed' and possible captured. Casualties would feed into higher level modelling.
3	Key event times (inc movement rates)	Time taken to achieve the key events in the mission (Key events as defined by Standard Operating Procedures. Subjective comments should describe the factors that had an impact on the time taken.)
4	Consumables	Primarily ammunition. Other items will become important with longer/larger missions.
5	Re-organisation time	Time taken between securing an objective and being ready to undertake the next phase of the operation, or the reason why the section were unable to continue.
6	Detection/ engagement ranges	The range at which the enemy was detected and the range at which effective fire could be opened (ideally coincident). Terrain & conditions dependent.
7	Quality of information (timeliness, accuracy, detail)	Subjective comment on the quality of information flow.
8	Detection avoidance (yes / no)	The measure of the ability to operate covertly. If detection does occur, range and characteristic used by the enemy in the detection should be recorded.
9	Ability to alert force	The measure of the ability of the sentry to alert covertly remainder of squad when the enemy has been observed.
10	Ambush quality	The overall ability to implement the ambush as planned. (Were extra instructions required.)
11	Spare	
12	Maintain 'traffic' flow	Ability to maintain traffic flow within the limitations of vehicle types, road characteristics and weather.
13	Security of post	The ability to control physical access to a location.
14	Crowd casualties	Crowd casualties expressed as absolute numbers killed or wounded requiring hospital treatment.
15	Spatial control	Ability to control crowd.
16	Suppressive performance	It may only be realistic to measure numbers 'killed' and possible captured. Casualties would feed into higher level modelling. The assessed effectiveness of the suppressive fire could consider own forces killed, incapacitated or captured such that they are unavailable for re-tasking at the end of the mission, expressed as absolute numbers for both.
17	Spare	
18	Debrief	A comparison of the information captured and reported to the information that could have been captured and reported.
19	Reinforcement	The time taken to obtain reinforcements and be available for tasking.
20	Re supply	The time taken to get consumables (eg ammunition) to the soldiers
21	Re-equip	The time taken to provide replacement equipment to the soldiers.
22	Equipment preparation	Time spent and what was done against time spend and what should have been done, preparing equipment for mission.

Ser	Collective MoE	Interpretation
23	Orders	Measures of the effectiveness of the C^4I process at each command interface. Metrics to be developed (see section 6).
24	Soldier preparation	Time spent in personal preparation.
25	Detection rate (i. e. how many found at time of declaration)	A measurement of the thoroughness of the searching for objects such as mines.

Table 3a: Measures of collective effectiveness at the vignette level

Ser	Collective MoE	Directly measurable in trials	Measurable by subjective opinion	Obtainable from combat simulation or modelling
1	Enemy casualties	x	x	x
2	Own casualties	x	x	x
3	Key event times (inc movement rates)		x	x
4	Consumables	x	x	x
5	Re-organisation time	x	x	
6	Detection/ engagement ranges		x	x
7	Quality of information (timeliness, accuracy, detail)	x	x	
8	Detection avoidance (yes / no)	x	x	x
9	Ability to alert force		x	
10	Ambush quality	x	x	x
11	Spare			
12	Maintain 'traffic' flow		x	
13	Security of post	x	x	x
14	Crowd casualties	x	x	x
15	Spatial control		x	
16	Suppressive performance		x	x
17	Spare			
18	Debrief		x	x
19	Reinforcement	x	x	
20	Re supply	x	x	
21	Re-equip	x	x	
22	Equipment preparation	x	x	
23	Orders	*	x	
24	Soldier preparation	x	x	

25	Detection rate (i.e. how many found at time of declaration)	x	x	

Table 3b: Measuring collective effectiveness

*to be reviewed when C2 aspects more fully addressed

5.5 Collective MoE applicable to each vignette

5.5.1 Table 4 relates the collective MoEs postulated in table 3a to the vignettes defined in table 2. Vignette goals set are also given in table 4.

Ser	Vignette	Vignette goal	Collective MoE
1	Advance	To advance	2,3,4,5,6,7,8
2	Ambush (Snap or deliberate)	Destroy enemy	1,2,3,4,5, 6,8,9,10
3	Armoured vehicle - destroy	Destroy vehicle	1,2,3,4,5,6
4	Attack (Quick and deliberate)	Defeat enemy	1,2,3,4,5,6,8
5	Building or bunker - assault	Defeat enemy	1,2,3,4,5
6	Control of Movement (e. g. convoy reserve demolition, passage of lines)	Control movement	2,4,5,7,12,13
7	Crowd Control (Benign or hostile, riot control)	Control crowd	2,4,5,14,15
8	Defence (Hasty or deliberate)	Defeat enemy	1,2,3,4,5,6,7, 9
9	Fighting Patrol	Defeat enemy	1,2,3,4,5,6,7, 8
10	Fire Support	Suppress enemy	1,2,3,4,5,6,7, 16
11	Observation Post (Concentrating on execution rather than insertion)	Observe enemy undetected	2,3,4,5,6,7,8,
12	Post Combat (Overlaps with pre combat)	Reconstitute	3,7,18,19,20, 21
13	Pre combat (Overlaps with post combat)	Be ready for mission	3,22,23,24
14	Recce Patrol (Includes OOTW mobile intelligence	Report information	1,2,3 (to gather and

	gathering)		pass info), 4,5,6,7,8
15	Search (e. g. mines)	To search area thoroughly (there is often nothing to find, but confidence in the thoroughness of the search is needed)	2,3 (to declare complete),4, 5,25
16	Security Could be gate or sangar duties in OOTW or perimeter or clearance patrols acting as part of a screen force	Preserve force security	1,2,4,5,6,7. 9 6 and 9 are both by time and distance
17	Withdrawal	To withdraw	1,2,3,4,5,6,7, 8

Table 4: Measures of Outcome proposed for each vignette

5.5.2 The term 'defeat enemy' means to kill, suppress, neutralise, disrupt, destroy the will to resist or stop him from carrying out his own orders. Doctrine does not merely perceive the enemy's destruction as being the only way to defeat him. Attacking the enemy's will to fight or attacking his cohesion may be just as effective a means of defeating him. This definition therefore allows a good deal of scope in how the mission is achieved.

6. Performance measurements associated with Command & Control

6.1.1 In essence successful command and control relies on understanding the superior commanders intentions, making a plan to achieve it and communicating this plan to the subordinates, by whatever means, in as brief, clear and accurate manner as possible. Once the operation begins, he must monitor the execution of the plan and make adjustments to meet changing circumstances in a timely fashion.

6.1.2 There is a requirement for performance metrics to address command and control process from the mission command to the lowest level of the force.

6.1.3 Measurement associated are currently identified as collective MoE 23 'orders'. The initial consideration of this aspect is that it can be treated as a specific capability at the soldier task level and thus may require no special consideration.

7. Recommendations

7.1 General

7.1.1 The soldier modernisation modelling community should be encouraged to adopt the measurement approach herein. The key advantage of the approach is that the modelling outputs, at the mission level, will be readily understood by the User.

7.1.2 A common framework will allow co-operation in model validation and development and in the exchange of trial data.

7.1.3 Missions undertaken by groups of soldiers within the infantry company should be built from individual vignettes. Mission level collective MoEs that best characterise the mission should be selected from the collective MoEs at the vignette level. Collective MoEs can be prioritised to suit national perspectives.

7.1.4 Consideration should be given to developing standard NATO vignettes and hence the tasks that comprise the vignettes so that the soldier capabilities can be identified and the MoE and MoP at the soldier level established on a common basis.

7.1.5 The MoEs at the individual soldier level associated with command and control should be further considered and their placement at level 2 confirmed.

7.1.6 The measurement scheme establishes that soldier effectiveness is based on the capability available to undertake a task. The capture of capability shortfalls can be established from a combination of modelling, baseline trials, expert opinion and historical analysis.

7.2 Link to WGIII modules approach and NATO ST decision

7.2.1 Modules to achieve improved soldier performance could be selected that overcome many of the deficiencies. Specifically, technology can be used to overcome shortcomings in the man and/or his training as well as improving his current equipment.

7.2.2 The key to being able to decide what options are available is to understand where performance has been inadequate and the probable cause.

7.2.3 However, the trade-off process for a particular nation may establish that the addition of a 'full set' of modules to overcome deficiencies is not possible due to cost or carried weight. Indeed, better soldier selection or improved training could possibly reduce overall costs.

7.2.4 The comparison of national needs expressed in a common format could provide a parallel approach to the 'modules approach' to determining whether to recommend to proceed to a NATO ST. Common capability deficiencies would provide a common basis for modernisation.

7.2.5 The need therefore would be for each nation to establish their capability deficiencies, the relative importance of those deficiencies, and how each is to be overcome (i.e. by better equipment, improved selection and/or training etc.).

7.3 OOTW

7.3.1 Further work is required to amplify the issues associated with OOTW.

7.4 C2 MoE

7.4.1 Further work is required to amplify the issues associated with C2 MoE.

8. Glossary of terms

APC	Armoured personnel carrier
BG	Battle group
FRV	Final Rendezvous
LAW	Light anti-armour weapon
LG	Land Group
MoE	Measurement of effectiveness
MoP	Measurement of performance
OOTW	Operations other than war
RV	Rendezvous
Sangars	Defensive position built above ground
VCP	Vehicle check point

References

1 NATO Land Group 3, Working Group 3 paper: Approaches to NATO Soldier System Components, 16 July 1997.

2 AC/225 paper: Operational Concept for the Dismounted Soldier, 14 February 1996.

Appendix 1 - Example vignette descriptions

8.1 Introduction

8.1.1 The following paragraphs outline possible example vignettes undertaken at the section (squad) level that could be used as definition of the generic activities that dismounted infantry undertake. National preferences may result in alternative vignettes descriptions.

8.2 Example vignettes

8.2.1 **Advance:** The advance is a transitional operation whereby the section (squad) moves from one specific task to another. The section (squad) may advance either as part of a larger organisation or as a single entity if it is involved on a patrol. The section (squad) commander will be required to:

a. navigate;
b. conduct observation;
c. check the disposition of his section (squad) (adjusting it accordingly, according to the ground and tactical situation);
d. keep station with other elements of the force; and respond to orders or information.

8.2.2 **Ambush:** A section (squad) may be required to take part in an ambush either as part of a larger organisation or as an entity in its own right (for example if it is operating as a patrol). The ambush may be a deliberate ambush with formal orders, a specific mission and likely to be in position for some time before being sprung or lifted, or a quick ambush mounted at short notice to take advantage of a fleeting opportunity. The vignette will cover the insertion and the execution of the ambush.

8.2.3 The ambush vignette is staged within a defensive setting. It lasts 11 hours and portrays a deliberate ambush. It includes quick battle procedure (including the receiving, preparation and issuing of orders, rehearsals and a full debrief on return). Half the ambush party will have recently returned from a recce patrol to ensure that fatigue is a factor in the vignette. The ambush will be set for around 4 hours before it is initiated.

8.2.4 **Attack:** The section (squad) attack vignette lasts some 25 - 30 minutes and describes a section (squad) in the attack operating within a company and platoon framework. The company has already been in action, having mounted an attack against a prepared defensive position. The section (squad) under examination is now acting as the lead section (squad) of the leading platoon in a company advance. The company has been warned of a possible enemy stay behind party and the company commander has delegated the task to the leading platoon commander.

The platoon commander has completed his combat estimate and decided that it is a section (squad) task. Additional fire support (mortars and machine guns) can be made available on subsequent runs (as can enemy artillery fire and or obscurants) to measure the effects of these additional factors. The Vignette starts at the conclusion of face to face orders by the platoon commander.

8.2.5 **Building/ Bunker Assault:** The Building/ Bunker Assault describes the actions of an 8 man section (squad) assaulting a house as part of a company sized operation. The house has not been prepared for defence and is occupied by 2 enemy who have good reserves of food and ammunition.

8.2.6 Fire support for the assault is provided by neighbouring section (squad)s. The house to be assaulted should comprise a cellar, ground and first floors with an attic space. The enemy oppose the entry, which is made on the first floor, and then move downstairs on a prescribed route.

8.2.7 **Control of Movement/VCP:** This mission describes the section (squad) acting as a traffic control point/VCP on a controlled route. This will be conducted as part of a larger operation. A section (squad) may be called upon to execute such a mission in war where there is a need to maintain close control over the movement of vehicle or pedestrian traffic past a critical point (such as a bridge or defile) or during OOTW to facilitate the free flow of traffic on routes which are narrow, in poor condition or run across front lines. The section (squad) will have to provide its own security as well as controlling the flow of movement.

8.2.8 **Section (squad) Defence:** The section (squad) defence vignette is drawn from a defensive scenario and is set within a company and platoon framework. It lasts some 13 - 15 minutes in the late afternoon. It describes the actions of one fire team within a section (squad) fighting off a deliberate attack from a prepared defensive position. The position should have been occupied for some 24 hours, during which time it has been **fully prepared**. The two 4 man fire trenches in the section (squad) have both shelter bays and overhead protection, a protective minefield has been laid and a wire obstacle constructed. The enemy have been active within the BG area since about 1000 hours, when recce passed through, and 2 attacks have already been beaten off.

8.2.9 **Fighting Patrol:** The combined Fighting Patrol/ Destroy Armoured Vehicle Vignettes are set in a defensive scenario. They are therefore set within a company and platoon framework. It covers a one hour twenty five minute period and describes a fighting patrol mounted to destroy an enemy combat recce patrol. The Vignette begins after the company has

spent the night preparing the defensive position, including laying a protective minefield and constructing wire obstacles. The platoon commander receives the order to mount a fighting patrol. He issues a quick warning order detailing off the strength of the patrol and the general outline, conducts his estimate and issues a short set of orders. Vignette activity should be recorded from this point onwards.

8.2.10 **Observation Post:** The Observation Post (OP) section (squad) mission describes the occupation and preparation of an OP position. No specific vignette has yet been written, but one may be drawn from a defensive scenario which is set within a company and platoon framework. The occupation and preparation of the OP described in this scenario covers a 5 hour period and encompasses: the move to the OP area; reconnaissance and selection of the final OP position: and the preparation of the OP including blocking access and preparing an escape route.

8.2.11 **Pre and Post Combat:** These activities are to be recorded as they occur within the context of other vignettes. The recording will commence once the section (squad) leader has received his orders from his commander. Since many of the post-combat activities are carried out with assistance from higher units, SOME of the measurement of this activity may have to wait until higher level trials are organized.

8.2.12 **Post-Combat:** The Post-Combat section (squad) mission describes the activities carried out immediately after combat has finished which are necessary so that commanders can restore full control over their command and regain situational awareness. it also allows essential logistic activity to take place. This includes:

a. providing ammunition and casualty returns;
b. giving first aid to casualties and evacuating the to the Company Aid Post;
c. the initial processing of prisoners;
d. searching enemy dead for items of intelligence interest;
e. repairing defences (in defence) or digging shell scrapes (in the offence).

8.2.13 **Pre-Combat:** The Pre-Combat section (squad) mission describes the essential activities necessary to launch the section (squad) into battle properly prepared. Pre-Combat activities fall into 2 main categories. Passage of orders and battle preparation. Passage of orders comprises: the receipt of orders from a superior; the issue of a warning order; conduct of recces; conduct of the combat estimate followed by the preparation and delivery of orders. Battle preparation covers the preparation of both the individual and his equipment prior to going into action. This includes the cleaning of weapons, loading of magazines, priming grenades etc; repackaging equipment, receiving and stowing specialist equipment, having a meal and even resting once all other preparations have been completed.

8.2.14 **Recce Patrol:** The vignette is drawn from an offensive Scenario. It portrays a recce patrol conducted to gather information on the strength and extent of an enemy position in order to inform the planning of a deliberate company attack. The vignette lasts for some 6 hours and begins with the 4 man patrol setting off on the task having received orders and conducted rehearsals. It encompasses the march out to a final RV, the close reconnaissance of the objective, the sending of the initial results of the recce (e.g. by coded radio message) and the return to the company position for fuller debriefing.

8.2.15 **Search:** An infantry section (squad) may be given the mission of conducting a search. Such a mission falls into 2 categories. In general war members of a section (squad) may be required to breach a minefield by hand, entailing them in crawling forward, prodding for mines as they move slowly forward. In OOTW a section (squad) may be tasked to search an area or a building for insurgent weapons and stores.

8.2.16 **Security:** An infantry section (squad) may be given the task of providing security in the form of a guard on an installation, providing control of access, sentries in sangars, patrols and a reaction force. Alternatively individuals within a section (squad) will act as tactical sentries on the edge of a position.

8.2.17 **Withdrawal:** A section (squad) will be given the task to withdraw as part of a company operation. Withdrawal may be conducted in or out of contact. Withdrawal out of contact is normally conducted by night. Withdrawal in contact is conducted using fire and manoeuvre until such time as it becomes possible to break contact with the enemy.

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Programs to enhance the capability of the dismounted soldier have been started in all the ABCA countries. Models and measures of effectiveness need to be in place to assess changes in the soldiers' capabilities due to enhancements to their clothing and equipment. A joint QWG AOR/TTCP workshop was held 27 to 31 January 1997 in Ottawa to discuss programs of work, available models, and measures of effectiveness. This research note contains a summary of the discussions held during the workshop. Agreement was achieved on a set of definitions and on a way ahead.

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